POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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Dr. C. G. Suits of the G. E. Research laboratory with his high pressure arc chamber.

UP-TO-DATE power plant engineers are, justly, proud of the progress made in the use of high steam pressures and temperatures during recent years. From pressures of around 400 lb. per sq. in. and temperatures of 600 deg., values considered high relatively few years ago, pressures and temperatures have crept upward steadily until today pressures of 2500 lb. and temperatures in the neighborhood of 1000 deg. are possible.

High as these values of pressure and temperature are they are set to shame by those attained in recent experiments with electric arcs in gases at the General Electric Research laboratory at Schenectady.

The hurricane that tore through New England last fall was the result of an area of very low barometric pressure moving up the coast from the south. Winds of devastating velocity swept everything before them; air velocities of well over a hundred miles an hour were recorded.

Strangely enough while nature produces such winds by a decrease in air pressure, scientists have produced winds of much greater velocity by increasing the pressure.

Working with gases at pressures of many tons per square inch and temperatures of more than 12,000 degrees, F.—much hotter than the surface of the sun—wind velocities of almost unbelievable values have been produced in the G. E. laboratory. At the same time a number of new facts regarding the properties of electric arcs have been discovered. They have found, for instance, that in hydrogen at high pressure it is not possible to maintain an electric arc, even briefly; the velocity of the gas is so high the arc is extinguished instantly.

In back of a barricade of sandbags and within a thick-walled cylinder of exceptionally strong steel different gases are compressed to pressures even as high as 3600 atmospheres. A switch is closed, and a heavy current arcs across the chamber. A thick fused quartz window permits the arc to be seen at such relatively low pressures as 200 atmospheres but for higher pressures the oscillograph must be relied upon to show what happens in the cylinder.

When the arc gas is heated it expands and becomes very bouyant and this buoyancy force gives rise to convection currents around the arc. As the pressure goes up so does the velocity and while the actual velocities have not been measured they are believed to be extremely high. Thus, by means of high pressures in completely closed chambers, the electrical engineer is able to attain high velocity gas blasts without the use of complicated pumps and auxiliary equipment; all of which may have a very definite bearing on future circuit breaker design.

WITH THE EDITORS

Seasoning for Metals

IF WE were asked to name the branch of science that has been most influential in advancing the art of power generation during the past 10 yr. our answer would be metallurgy, a branch of chemistry. The question is of course controversial for none of the sciences have remained static and they are all so interwoven in their applications that it is extremely difficult to give credit to one without honorable mention of all the other applied sciences. In the past decade, however, metallurgy has come to the rescue of engineers in countless applications of scientific principles that heretofore have been dormant.

Far above all other advances in the power field that have increased efficiency and economy during this period has been the application of steam at higher pressures and higher temperatures. For many years scientists have been aware of the thermodynamic advantages of using steam under just such conditions as are now being applied to best advantage, but engineers were thwarted at seemingly every turn because metals were not available that would handle steam at its theoretically best conditions.

It seems but a few years ago that reports were coming from all parts of the country of disastrous explosions and failures of vessels containing superheated steam under such pressures as 250 lb. and 550 deg. temperature. Investigations in many cases placed the cause on the creep in the cast iron then commonly used for fittings and certain parts of vessels. Today metals are available that will withstand steam at any desired pressure and temperatures up to 1000 deg. F. without danger of rupture. Design of equipment to provide for expansion and contraction must also be given credit for its share in making the practice safe, for failures in this field are extremely rare today.

To gain an idea of the extreme care with which boiler metals are selected one needs only to refer to the article on the Delray station in this issue where the specifications for tubes in various parts of the boiler are given.

While boilers, piping and turbines are the fundamental equipment effected by higher pressures and temperatures much of the success of this change in practice has been due to the use of special alloys in the design of auxiliary equipment such as valves, soot-blower nozzles, stoker and burner parts, refractory supports and other details affected by temperatures and pressures. The art of welding in all its branches is a development of metallurgy made successful and popular through the availability of suitable electrodes.

Corrosion, the arch enemy of nearly all ferrous metals a generation ago, is now fairly well under control through the addition of small quantities of nickel or chromium to the iron. Likewise erosion is minimized and the life of equipment lengthened by the use of tungsten and vanadium in parts subject to abrasion Here again surface welding is performing an extremely important service. It is interesting to note also that, as reported at the Midwest Power Conference, copper-clad transmission wire has made possible substantial savings in the construction of rural electric lines. Many advances in the design of electrical power equipment are directly responsible to metallurgical developments that have improved magnetic characteristics and reduced the necessary size of units.

Used in quantities comparable to seasoning in foods, some of the rarer metals impart qualities to ferrous, copper, lead and other common metals that have not only multiplied their uses but vastly improved services for which they have long shown superior qualities. Research is rapidly increasing the available knowledge of metallic alloys and the power industry is one of the greatest benefactors.

Why Tinker?

MEN ENGAGED in the operation of power plants have always been of inventive natures, which probably is the case in every new and progressing industry. This fact unquestionably is one of the main reasons why the industry goes forward. The desire to improve efficiency, simplify construction and operation, reduce manual labor, reduce the possibility of accidents and improve economy is inherent in qualified engineers. With some, the ambition to do something different or novel runs riot with the result that their inventions are frequently entirely without merit.

No fault can be found with the judgment of an engineer who in an emergency resorts to an expedient that keeps a plant running until adequate repairs can be made, nor with the man who has definite problems to solve and, failing to be able to secure the equipment he needs from the market, builds or has built for him the exact equipment he requires, but the inveterate tinkerer who is continuously toying with manufactured machinery with neither the scientific knowledge nor the mechanical skill to improve the device is more likely to cause more trouble than improve conditions.

It is true that the conception of nearly all manufactured equipment has come from the people who most need it, once built and successfully used only demand in sufficient quantities to make manufacture and improvement profitable will insure its continuance on the market. Seldom is it possible for the operating engineer to improve a device that has become standard in the field. Such equipment is usually the result of long and successful service under the watchful eye of trained operators and research experts with every facility at their command to investigate possible improvements that may be suggested.

When manufacturers find that their products are frequently being changed by the users, it is high time that they investigate the reasons, for in normal operation changes are made only when a need is indicated. Seldom is the home-made device comparable with the one that comes from an established factory but there is always room for improvement and to this end the inventive engineer is lured as an amateur with the hope of discovering something that has commercial value.

Louisiana Ice & Electric Co. completes what is thought to be the largest gas engine electric generating station*, a 3750 kv-a. plant, with three convertible gas-Diesel units, built at a total cost of $338,353.81 in 6 mo. time.

Gas Engines for Louisiana Utilities

By

F. H. COUGHLIN

Vice President
Louisiana Ice & Elec. Co., Inc.
Alexandria, La.

REA GENERATING STATION of Louisiana Ice & Electric Co., Inc., started full operation on November 20, 1938. This plant addition consists of three 1250 kv-a. generators direct connected to three twin-six internal combustion engines. With this addition Rea Station becomes the principal generating station of Louisiana Ice & Electric Co., Inc., which serves approximately 6,000 utility customers in small communities and rural territory, extending some 100 mi. north and south and 50 mi. east and west in Central Louisiana as shown by Fig. 1. Bunkie, where the station is located, is the load center of this system. Service for this interconnected system has been provided hitherto by an 812 kv-a. oil engine generating plant at Pineville plus power purchased at Opelousas. A number of small Diesel plants have served as standby, the largest, of which, a 735 kv-a. attended station, was at Bunkie.

During the last 3 yr. the number of customers served has doubled. This marked increase made necessary a revision of service facilities either through an increase in transmission facilities or generating-plant capacity. Economic considerations dictated the latter. The size of the additional generating facilities required, 3000 kw.* lead to serious consideration of steam plant possibilities but, a careful comparative study standpoint, led to the choice of internal combustion engines. The principal arguments leading to this decision for this specific installation were:

*Rea Station described in this article was named for Robert W. Rea a Director of Louisiana Ice & Electric Company, Inc. F. W. Woodcock is President of this Company as well as of the Crescent Public Service Company of Wilmington, Delaware, and the Central Ohio Light & Power Company of Findlay, Ohio, which last year completed Woodcock Station at Bluffton, Ohio, a 450 lb., 825 deg. F. steam plant described in the October 1938 issue of POWER PLANT ENGINEERING.

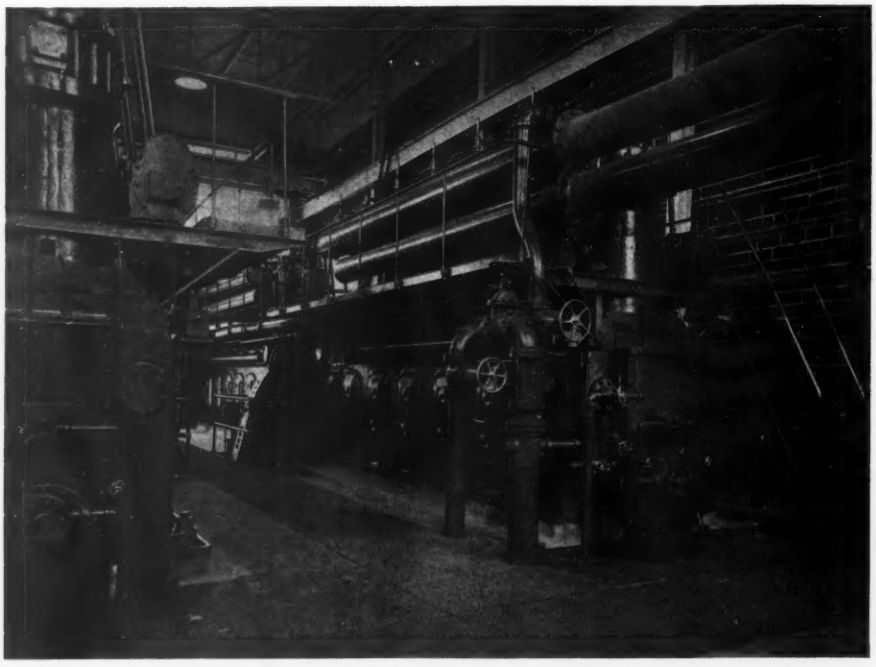


Fig. 1. One of the twin six cylinder engine units with the generator located between them

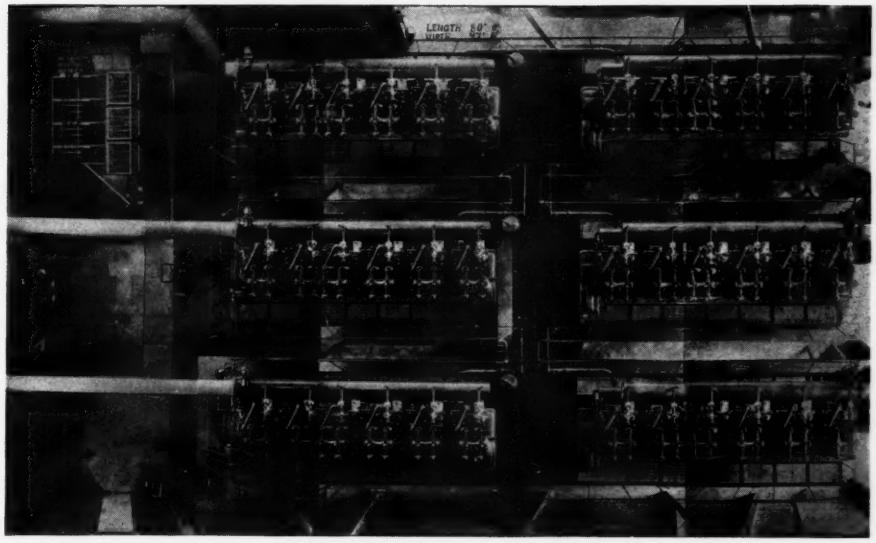


Fig. 2. (Left) Looking Down On the Diesel, or, a Steam Engineer's dream. Unusual view of the station interior taken with the camera lens pointing vertically downward. Each unit consists of twin six cylinder Worthington vertical gas engines with the generator between them. In this picture the generators are hidden by the grating but the arrangement can be seen clearly in Fig. 1. The switchboard is in the upper left hand and the auxiliary pumps in the lower left hand corners

1—The plant cost per kw. installed was estimated to be somewhat lower for the engines.

2—Fuel and lubrication costs for the engines were estimated to be much less than for turbines.

3—High temperatures and relative humidity emphasized the water problem; any suitable site was a considerable distance from existing facilities.

4—The Diesel standby plant at Bunkie had attendants who could be employed as operators of additional units installed there.

Of the various elements involved in our studies, the most unusual was the character of fuel supply available. This plant employs natural gas obtained directly from a small gas-oil field some 27,000 ft. distant. The gas available has a heat value of 1156 B.t.u. and, at the source, is high pressure gas which has been employed, in lifting oil and would be wasted were it not utilized in this manner. The life of the field is uncertain being dependent primarily on the rate and efficiency with which oil is produced, nevertheless, a supply is assured for a few years. Thereafter natural gas will be available from trunk pipelines, and possibly from other nearby structures which may be drilled.

Table 1. Breakdown of Station Cost.

Land and Land Rights		$ 479.95
Structures and Improvements:		
Foundations	$ 13,050.01	
Building Extension	11,736.34	
Labor on Building Extension	3,225.54	
Total		28,011.89
Internal Combustion Engines		
Engines	218,324.46	
Labor and Expense installing engines	6,600.93	
Spare Parts	143.37	
Freight	11,454.84	
Closed Cooling System	5,612.59	
Labor on Cooling System	156.68	
Jacket Water Pumps	594.17	
Labor on Water Pumps	118.79	
Cooling Tower Pumps	510.24	
Labor on Cooling Tower Pumps	37.84	
Valves, Fittings, Piping, Etc.	6,435.86	
Labor on Valves, Fittings, Etc.	1,736.41	
Cooling Tower	3,676.03	
Labor on Cooling Tower	912.53	
Oil Purifier	1,083.12	
Total		257,397.86
Generators:		
Generators and Split Rotors	26,027.84	
Labor on Generators	538.11	
Exciters	2,092.58	
Total		28,658.53
Accessory Equipment:		
Switchboard	8,830.69	
Labor on Switchboard	490.65	
Circuits and Feeders	1,490.93	
Labor on Circuits and Feeders	477.24	
Total		11,289.51
General Expense:		
Engineering and General Expense		7,705.25
Taxes (Including 1% "Use Tax")		3,740.01
Insurance		1,070.81
Total Cost		338,353.81

It was decided, therefore, to use natural gas for fuel, but to hedge against future fuel costs by employing an engine which, with cylinder changes, could be utilized as a Diesel engine. Had the plant been designed as a strictly gas-engine plant considerable weight and first cost might have been saved. The heavier running gear, however, is expected to pay dividends in the form of decreased maintenance costs.

The layout of the plant, which is 80 by 47 ft. 6 in and which has proved to be compact and effective, is shown by Fig. 2. The foundation for the three-twin-six engines and generators is a monolithic reinforced concrete structure 43 ft. 4 in. by 57 ft. 9 in. and 8 ft. thick resting on thirty 30 ft. and one hundred and thirty-five 21 ft. piles driven on 4 ft. centers. A concrete pipe trench with steel plate covers extending the width of the plant contains a 12 in. gas header, 12 in. inlet and outlet water headers, cable and lighting conduits. Adjoining parallel trenches extending the width of the plant at each end of the engines contain each three engine-oil sump tanks and three oil coolers. Three similar though smaller trenches extending at right angles contain conduit, gas and water lines for service to each unit.

Particular attention was given to exhaust noise elimination which was effectively accomplished with Maxim Silencers; to the control of frequency which appears to have been met with Woodward governors; and to control of cooling water quality which is definitely achieved with an enclosed water system built up with Griscom-Russell Bentube sections. A list of principal items is given on the next page.

Including gas lines and facilities, the project was essentially engineered and built by the Company's operating personnel. A portion of the building and

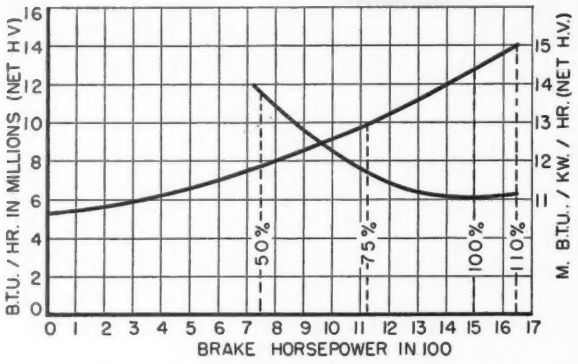


Fig. 3. Performance of the units based on shop test data. Note that these curves are based on the net heating value of the gas instead of the more common gross value

foundation work was done by a local contractor. Much credit is as usual due to engineers for equipment companies:—General Electric Co., Westinghouse Elec. & Mfg. Co., and in particular A. M. Lockett & Company, Ltd., for the Worthington Pump & Mach. Corp.

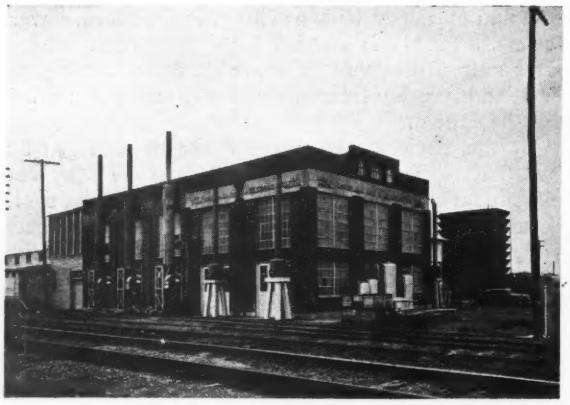


Fig. 4. The new station has a total generating capacity of 3750 kv-a. in three units, each generator driven by a 1500 hp. twin six gas engine

Costs, excluding gas transmission lines, electric substation additions and expense incident to financing were as shown by Table I.

The first firm contract for material was placed on May 28, 1938, and the first unit was "on the line" on October 19, 1938. On November 13 all three units were ready for service. At this writing data have not been accumulated on operating experience and costs, however, factory test runs on the first engine gave results shown graphically by Fig. 3. Special attention, perhaps, should be directed to the fact that the B.t.u. are "net" heat values, consequently, some 10 per cent less than the gross heat values of common reference.

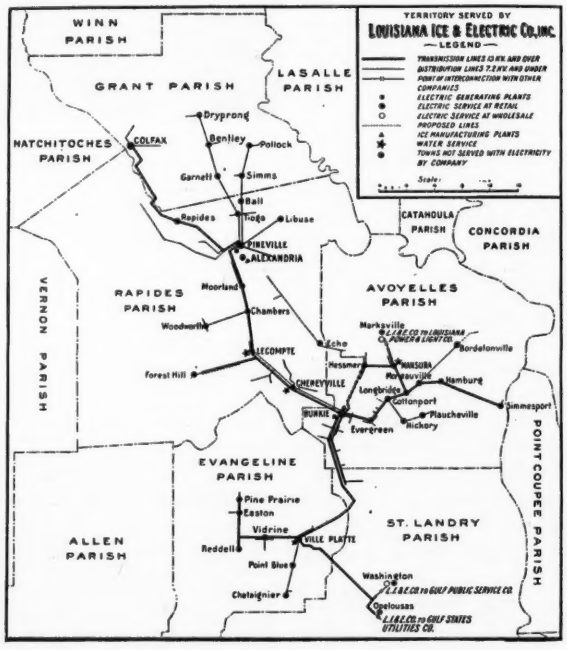


Fig. 5. System map showing the location of the new Rea Station

PRINCIPAL DATA ON, AND EQUIPMENT IN, REA STATION

ENGINES

3 Worthington twin-six, 4 cycle, 18x25 gas engines rated at 1500 hp. each at 225 r.p.m. Engines are equipped with Woodward governors, Scintalla dual ignition system and D04 Maxim Silencers. Force feed lubrication on cylinders and all bearings. Lubrication of cylinders with Manzel force feed lubricators, bearings lubricated by oil pump driven directly from the crankshaft. Supply consists of one 300 gal. capacity sump tank at each end.

ALTERNATORS AND EXCITERS

Directly connected to each gas engine unit is a 1250 kv-a., 2400 v., 3 ph., 60 cycles, 225 r.p.m. Westinghouse alternator with a 25 kw. v., 1750 r.p.m. Westinghouse d.c. generator, driven from the main shaft with a Morse silent chain drive, for excitation.

SWITCHBOARD

Switchboard and switch gear furnished by General Electric consists of: one swinging panel; one regulator panel; 3 exciter panels; 3 generator panels; one feeder panel, and provision for an additional generator unit by one blank exciter and one blank generator panel. All instruments are flush mounted and breakers are operated by bell cranks 10 ft. behind the face of the switchboard, giving ample space for maintenance. Local distribution circuits are fed through the bus bars of an existing switchboard enabling a tie-in of both sections.

JACKET WATER AND COOLING SYSTEM

3 Worthington motor driven 70 ft. T.D.H. jacket water centrifugal pumps, one with a capacity of 1200 and two with a capacity of 600 g.p.m. These pumps all discharge through 6 in. laterals into a common 12 in. header with a 12 in. pipe leading to the outdoor Bentube cooling sections. These latter sections are arranged in such a manner that one-half can be cut in or out at the operators convenience. Raw water for cooling is supplied by 232 spray heads in a 36 ft. by 95 ft. 10 in. Binks cooling tower and pumped by 3 Worthington motor driven centrifugal pumps of 1200 g.p.m. capacity, against a T.D.H. of 35 ft.

GAS

One of the most unusual features in connection with this job was the character of fuel supply which as previously noted is natural gas. The gas supply is obtained from a small gas-oil field located some 27,000 feet distant from the plant to which field the Company built its own pipe line. A 4½ in. pipeline handles the daily requirements of the plant with a pressure drop of approximately 25 lb. at an upstream pressure of 70 lb. The gas is obtained directly from the gas wells and is gas which has been employed in lifting oil, consequently, would be wasted if it were not utilized in this manner. The gas has a gross heat value of approximately 1160 B.t.u. per cubic foot.

Air Heater and Economizer Selection

Part I. Elementary theory of heat transfer and draft loss serve as a starting point in determining whether an air heater, economizer or both should be installed. In Part II the theory is applied to specific plant conditions to show its applications in practice.

By ADOLF JOHNSON

SUPPLYING STEAM at maximum thermal efficiency consistant with economic return rests chiefly on one fundamental concept which can be briefly termed—availability. By availability is meant the available temperature head or difference between the heat transmitting medium and the heat receiving or absorbing medium. With the increasing demand for high temperature, high pressure steam for modern high and medium capacity units, the question of availability becomes more important in the design of efficient steam generators.

Heat transmission to the water and steam is, of course, accomplished by a combination of three fundamental means: Radiation; convection, and conduction. Since all the absorbing mediums in the complete steam generating unit are of metal which have extremely high conduction rates, we can eliminate conduction in this elementary analysis. This leaves radiation and convection as the medium of transferring available heat to useful high pressure, high temperature steam.

This is where the availability problem comes in. Starting in the furnace the temperature of the gases of combustion are very high, and the temperature head available between these gases and the front row of boiler tubes is extremely high. This is where heat transmission by radiation rules supreme. Transfer rates per square foot of heating surface for radiation alone is three or four times the maximum obtainable by pure convection at any other portion of the steam generator.

Radiation vs. Convection

As much as 40 per cent of the total heat absorption by the steam is accomplished in the furnace by radiation. Although radiation is an efficient means of heat transmission at high availability, it becomes decreasingly unimportant as the gases pass through the boiler, until at the boiler exit it is practically a negligible factor. Convection heat transmission assumes an increasingly important role in transferring the available heat in the gases to steam as the gases pass through the boiler. However, the temperature head or availability is decreasing because, although the boiler absorbing surface temperature remains constant, the flue gas temperature is dropping.

At the boiler exit, the temperature difference between flue gas and boiler surface is such that the addition of more boiler heating surface would not effectively reduce the flue gas temperature. Or it might be stated that the amount of additional boiler surface required to effectively reduce the boiler exit temperature would be far beyond the limit of the economical first cost of the equipment. Even should it be economical to do so, the availability becomes zero when the flue gas temperature reaches the saturated steam temperature in the boiler.

As a matter of fact, flue gas temperatures leaving the boiler are usually 200 to 400 deg. F. above the saturated steam temperature. Other factors such as water and steam circulation and moisture content of the steam leaving the boiler enter into determination of boiler heating surface, so that the boiler size for a given capacity is more or less fixed. It cannot so easily be considered as a flexible medium in the selection of a unit for low boiler exit gas temperature or high thermal efficiency.

Economizers

In order to reduce the exit gas temperature, the logical step is to increase the availability so that as much of the available heat as possible will be transferred to the absorbing medium. No more heat can be transferred to the steam since the availability is too low. The next logical step is to increase availability by transferring heat to a lower temperature medium. This leads to two possibilities, transfer the heat to the relatively low temperature feedwater and the very low temperature air required for combustion of the fuel.

Feedwater temperatures range anywhere from 210 to 450 deg. F. The average air temperature is 80 deg. F. Since the air temperature is so much lower than the feedwater temperature, one is first led to believe that the answer to the problem of economically increasing thermal efficiency is to transfer the heat in the flue gas, leaving the boiler to the air required for combustion, since there is a higher temperature difference between the flue gas temperature and the air temperature than between the flue gas temperature and the feedwater temperature.

A more detailed picture of how the heat is transferred from the flue gas to the air or the feedwater, and, of the inherent thermal characteristics of these heat absorbing mediums will, however, show that there are occasions when pre-heating the air is not the most advantageous. In fact, it is sometimes economical to both pre-heat the air and the feedwater, to obtain the most economical unit from the standpoint of cost and thermal efficiency. There is no hard and fast rule to follow and each case must be decided by an intelligent application of the theoretical and practical factors which influence the design of air heaters and economizers.

When to use an economizer, and when not; when to use an air heater and when not; when to use both and when not is an important practical question.

Digging into fundamentals again, it is known that both air and feedwater are not constant temperature absorbing mediums such as saturated steam and water in the boiler. In other words, as air and water absorb

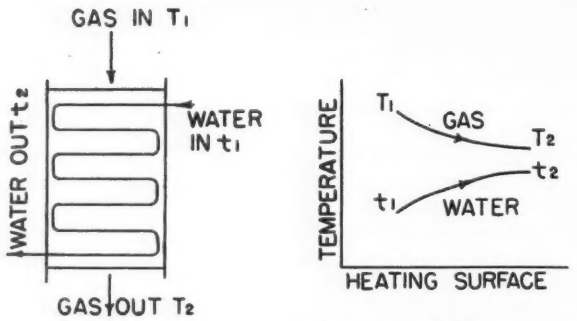


Fig. 1. Illustrating the temperature relations in parallel flow economizers where the hot gas and cold water enter the same end and travel parallel to each other

heat their temperature increases accordingly. This is a disadvantage which cannot be overcome, and one can only make the best of it.

Previous reference was made to the fact that although the temperature difference between flue gas and air entering the unit is greater than the difference between flue gas and feedwater entering the unit, it does not mean that an air heater is always the answer to efficient heat absorption. The reason for this is, as stated above, that these heat absorbing mediums are not of the constant temperature type, nor do they have the same thermal characteristics.

Temperature Difference

To clarify this further, absorption of heat at each point throughout the economizer or air heater is dependent on the corresponding temperature difference between the flue gas and the heat absorbing medium at each point. As the air or water absorbs the heat, the flue gas temperature is decreasing and the absorbing gas or fluid temperature is increasing. The availability, in other words, is decreasing at a greater rate through an economizer or air heater than through the boiler absorbing surface, bearing in mind that although the gas temperature drops through the boiler, the absorbing medium is at constant saturated steam temperature throughout the boiler.

So far the economizer and air heater have been discussed as similar types of heat absorbing equipment. In order to determine the relative merits of the two, the differences must be established to serve as a basis of choice in connection with any specific problem.

The diverging path between air heaters and economizers as heat absorbing devices starts with the inherent thermal properties of the heat absorbing mediums themselves. For instance, the specific heat of water is approximately four times the specific heat of air. This means that for a given drop in flue gas temperature in giving up its heat, the air temperature would increase about four times as much as the water temperature. The availability or temperature head therefore decreases faster in an air heater than in an economizer due to this fact.

An example will illustrate this more clearly. Assume that the boiler exit gas temperature is 600 deg. F. and that 50,000 lb. of gas per hr. is leaving the boiler at this temperature. Let the temperature leaving the economizer or air heater equal 350 deg. F. and the average specific heat of flue gas leaving the boiler as 0.26 B.t.u. per deg. F. Also assume the following:

W_g—weight of water to economizer, 40,000 lb/hr.
W_a—weight of air to air heater, 42,000 lb/hr.
C_a—specific heat of air, 0.24 b.t.u./deg. F.
t_1—temperature of water to economizer, 210 deg. F.
t_{a1}—temperature of air to air heater, 80 deg. F.

Water temperature rise is

$$50{,}000 \times (600\text{-}350) \times 0.26/40{,}000 \times 1.00 = 81 \text{ deg. F.}$$

Temperature of water leaving economizer is

$$210 + 81 = 292 \text{ deg. F.}$$

Air temperature rise is

$$50{,}000 \times (600\text{-}350) \times 0.26/42{,}000 \times 0.24 = 322 \text{ deg. F.}$$

Temperature of air leaving air heater is

$$80 + 322 = 402 \text{ deg. F.}$$

The average availability of an economizer or air heater is not the arithmetical difference in temperature between the heat transmitting and heat absorbing mediums at the point where the flue gas enters the heat absorber, but it is the log mean temperature difference, which takes into account the fact that the temperature head is a variable from entrance to exit of the air heater or economizer. The log mean temperature, it can be proved, is the temperature difference at the inlet minus the temperature difference at the outlet divided by the $\log_e$ of the ratio of temperature differences.

There are two fundamental methods by which the heat transmitting and absorbing mediums may flow into the heat absorber. They are specifically known as parallel flow and counterflow. Parallel flow is established when the flue gas and absorbing fluid enter the unit at the same point and leave at the same point. This is illustrated in Fig. 1 where the gas enters the top of the economizer and water enters the tubes at the top also. Both water and gas flow downward or in a general direction parallel to each other. Counterflow is established when the two fluids flow in opposite directions as illustrated in Fig. 2, when the water is leaving the economizer at the point where the gas enters.

In economizers and air heaters, counter-flow is used almost exclusively since the theoretical availability is higher. In other words, for a given absorption the log mean temperature difference is higher with counter-flow than with parallel flow. Reference to the curves accompanying Fig. 1 and 2 will serve to show the reason for this. With parallel flow as the gas travels through the economizer its temperature is

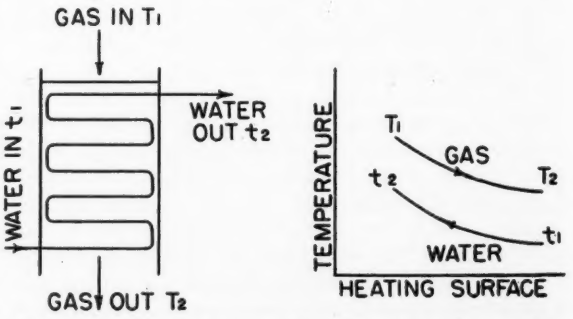


Fig. 2. In a counter flow economizer the water and gas enter at opposite ends so that the hot water leaving the economizer is heated by the hot gasses just entering

dropping off and the water temperature is increasing so that the availability is decreasing very rapidly. The counter-flow curves show that as the gas crosses each row of tubes and its temperature decreases, the water temperature is also at a lower level. Therefore, the availability throughout the economizer is maintained at as near a constant as possible, thus resulting in a higher log mean temperature difference than with parallel flow.

Referring to the example given previously, if the log mean temperatures are calculated for parallel and counter-flow, it will bear out the conclusions expressed above. In this example, we have the following temperatures for the economizer:

$T_1 = 600$ deg. F.—flue gas temperature entering
$T_2 = 350$ deg. F.—flue gas temperature leaving
$t_1 = 210$ deg. F.—water temperature entering
$t_2 = 292$ deg. F.—water temperature leaving

Calculation of log mean temperature difference t_m for counter-flow.

$T_1 = 600$	$T_2 = 350$	Temp. Diff. at inlet $= 308$
$t_2 = 292$	$t_1 = 210$	Temp. Diff. at outlet $= 140$
308	140	168

$$t_m = \frac{308 - 140}{\log_e \frac{308}{140}} = \frac{168}{0.79} = 213 \text{ deg. F.}$$

Parallel Flow.

$T_1 = 600$	$T_2 = 350$	Temp. Diff. at inlet $= 390$
$t_1 = 210$	$t_2 = 292$	Temp. Diff. at outlet $= 58$
390	58	332

$$t_m = \frac{390 - 58}{\log_e \frac{390}{58}} = \frac{332}{1.91} = 174 \text{ deg. F.}$$

In the temperatures given in the previous example for air, the air exit temperature was 402 deg. F., which is higher than the exit gas temperature. Since it is obviously impossible to obtain an air temperature leaving an air heater higher than the gas temperature leaving, the only method by which this air temperature can be obtained is by counter-flow of gas and air. The counter-flow mean temperature difference for the air heater, calculated as shown above, would be 232 deg. F. It will be noted that in spite of the low entrance temperature of the air in comparison to the water entrance temperature, there is not appreciable difference in log mean temperature difference for the air heater and economizer.

The heating surface required to obtain a certain heat absorption is expressed in the formula:

$$S = (T_1 - T_2) \times c_g \times W_g \div t_m \times U \qquad (1)$$

where:

S —heating surface, sq. ft.
T_1—gas entrance temperature, deg. F.
T_2—gas exit temperature, deg. F.
W_g—gas weight to economizer or air heater, lb. per hr.
c_g—average specific heat of flue gas, B.t.u. per lb. per deg. F.
t_m—log mean temperature difference, deg. F.
U —heat transfer rate, B.t.u. per sq. ft. per deg. F. per hr.

Since the heat transfer rate is an important factor in selection of economizer and air heater size, it is essential to include some discussion as to comparative values for these two types of heat absorbing apparatus. Heat transfer as previously mentioned is accomplished by convection and radiation, but radiation is negligible in the low temperature range where these heat traps are employed. The total heat transfer rate from the flue gas to the heat receiver is the resultant of several component transfer rates on both sides of the metal separating the heat transmitting from the heat receiving medium.

If both mediums are gaseous as is the case with an air heater, there exists a convection transfer rate compotent on the gas side and air side. The amount of heat that the air will absorb depends not only on the rate of transfer on the flue gas side but also on the rate at which the air will take the heat from the gas. The overall transfer rate U is obtained by combining the individual gas and air convection transfer rates by means of the reciprocal law.

Expressed in algebraic terms the formula is:

$$\frac{I}{U} = \frac{I}{U_g} + \frac{I}{U_a} \qquad (2)$$

where U_g and U_a are the gas and air transfer rates respectively. Simplified, the transfer rate U is equal to the product of gas and air transfer rates divided by their sum. Assuming the transfer rate is 8 for both gas and air, the effective overall transfer rate would be:

$(8 \times 8) \div (8 + 8)$ or 4 B.t.u. per sq. ft. per F. per hr.

From Eq. 1 the required air heater surface to reduce the exit gas temperature from 600 to 350 deg. F. would be:

$$S = (600\text{-}350) \times 0.26 \times 50{,}000 \div 4 \times 232$$
$$= 3500 \text{ sq. ft.}$$

The transfer rate U in an economizer is derived similarly except that the water transfer rate is so high that it has negligible effect in reducing the gas transfer rate. Due also to smaller economizer tube diameters the gas transfer rate is higher in comparison to the gas transfer rate for an air heater for constant gas velocity. The gas transfer rate can be still further increased through economizers by increasing the gas velocity. This is permissible because the increase in velocity of gases in an economizer will still result in a draft loss comparable to that through an air heater.

Gas transfer rates of 11 to 14 are not uncommon in practice for economizers. An assumed value of 12 is fairly representative. Since the water transfer rate is practically infinite, the overall or resultant transfer rate U would still be 12. On this assumption and by application of Eq. 1 the required economizer heating surface for the same performance as the air heater would be:

$$S = (600\text{-}350) \times 0.26 \times 50{,}000 \div 12 \times 213$$
$$= 1270 \text{ sq. ft.}$$

This is much less surface than required for an air heater; however, it must be kept in mind that since the economizer tubes surround water at least as high a pressure as the steam in the boiler, these tubes must be designed to withstand this pressure. This would probably bring the cost of this economizer up to the cost of the larger air heater.

So far transfer rates have been discussed without especial reference to draft loss. Draft loss is a definite factor to be taken into consideration in a complete analysis of the economics involved in selecting air and water preheaters. Draft loss represents a definite loss in that fan power must be expended to supply sufficient draft to drive the gases through the heater. Since convection transfer rates increase only approxi-

Continued on page 307

High Speed Diesel Indication

BY JOHN GEYER WILLIAMS
Experimental Engineer, Superior Engine Div.,
National Supply Co., Philadelphia, Pa.

ENGINEERS, in developing the high speed Diesel and gasoline engines to their present level of perfection, have been handicapped to some extent by the lack of a reliable and accurate indicator. Despite the exceptional mechanical ingenuity of most engine indicators, the many unpredictable errors from various causes made the results obtained by their application to engines somewhat questionable, and therefore much research has been based upon horse-sense and a study of the effect rather than the cause of combustion phenomena.

With the ever increasing search for more power through improved thermal and mechanical efficiencies, it has become more necessary to have an accurate picture of the actual combustion process and this need has been met by the cathode ray oscillograph as used for engine indication.

While it is not the intention of the writer to discredit mechanical indicators, it is necessary to point out the most common limitations so that the advantages of the electrical indicator can be fully appreciated. The two chief sources of error are: first, the mass of the moving parts actuated by pressure, and second, the connecting passageway conducting the pressure impulses from the clearance space to the indicator. On account of the mass inertia, the recording mechanism can register only comparatively low frequencies with any degree of accuracy. Resonant pressure wave and throttling effects are practically unavoidable in the connecting passageway, especially if appreciable changes in the compression space are to be minimized.

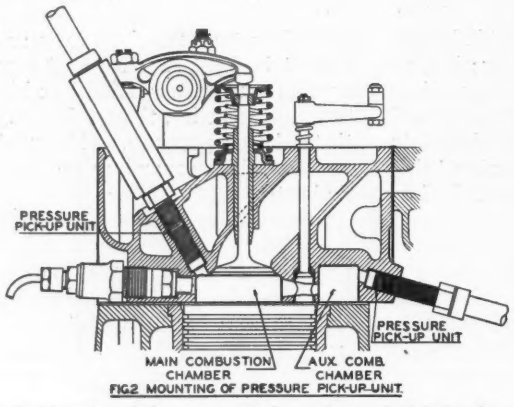


Fig. 2. Mounting of the pressure pickup units, at the left for the main combustion chamber, at the right for the auxiliary combustion chamber

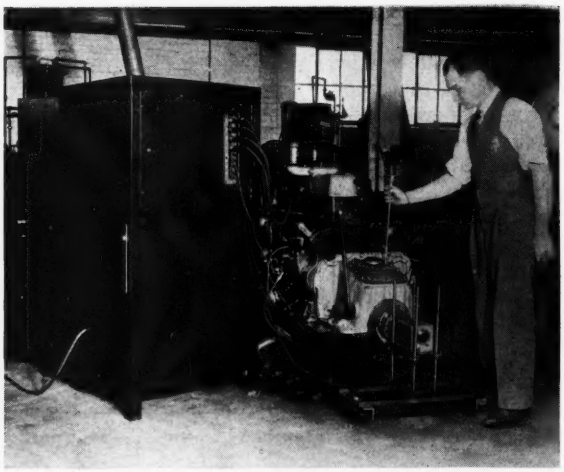


Fig. 1. The author, test engine and back view of the cabinet he designed to house the electrical equipment

The complete equipment consists of five main parts: 1, the pressure pickup, Fig. 2; 2, a voltage amplifier which amplifies the 50 mv. output of the pickup to 150 v.; 3, the cathode ray oscillograph which incorporates a sweep circuit and shows on a screen either a pressure-time or rate-of-change-of pressure-time card; 4, a synchronizer (visible at the end of the shaft) which synchronizes the sweep circuit with the rotation of the engine and also furnishes a marker voltage which can be superimposed on the screen to measure angular displacement from top dead center; 5, necessary switches and controls. Parts 2, 3 and 5 are mounted in the top third of the cabinet behind the panel and are accessible from the front. The four heavy cables go to separate pickups located in different parts of the engine. The author is holding a vibration pickup unit.

Among the various oscillographs used for engine indication, the chief difference in design is in the pickup unit. Generally speaking these pickup units can be classified into two distinct groups, namely: those in which the generated voltage is proportional to the rate-of-change-pressure rise and those in which the generated voltage is directly proportional to the pressure. Theoretically, at least, both principles are equally suitable for engine indication because differentiation of the pressure-time diagrams to the rate-of-change-of-pressure time cards or vice-versa can be accomplished easily with little distortion by using the proper electrical circuit. It is essential, however, that the pressure pickup be able to withstand the direct flame and pressure of combustion with no distortion from heat or resonance at frequencies up to at least 15,000 cycles per second.

The R.C.A. pressure pickup unit, with which the writer is most familiar, is designed to utilize the piezo-electric properties of quartz crystals which are ideally suited to meet the specifications of temperature, pressure and frequency, the basic requirements for a pick-up unit. If pressure is applied to the parallel faces of a properly cut crystal, an electrical voltage charge will appear on each face. The piezo-electric sensitivity constant does not change up to 400 deg. F. or greater. Somewhere above this temperature, around 1100 deg. F., the crystalline structure changes from the alpha to the beta state, which is accompanied by the loss of this piezo-electric property . On cooling down from the beta to the alpha form the piezo-electric sensitivity returns unchanged in magnitude. The proportions of the quartz crystals used in the pickup units are such that their natural frequency is above 1,000,000 c.p.s.

Since the minute voltage output from the pressure

pickup unit usually is less than 50 mv. even at combustion pressures, a voltage amplifier is necessary. From the amplifier the magnified voltages generated in the pickup units are conducted to the cathode ray tube of the oscillograph.

A series of tests were performed to check the accuracy and durability of this indicating equipment. Extreme limits of temperature and pressure were applied to the pickup unit and also frequency response tests were made of the complete apparatus. These tests demonstrated the absence of distortion from heat, nonlinearity and resonance. In actual engine test work, which is the proof of the pudding, this indicator was consistently reliable under a wide variety of operating conditions. A brief summary of the advantages of this type of equipment in engine indication follows:

At the last annual meeting of the S.A.E., the author presented a paper, Engine Indication with the Cathode Ray Oscillograph, outlining his experience with the R.C.A. oscillograph and piezo-electric pressure pickup on high speed Diesel work. A large part of the paper dealt with descriptions of the equipment, its application to Diesel testing, calibration and experimental work to determine operating limits and the effects of extreme pressure, temperature and frequency. The portion of the paper reproduced here deals with the practical application of the equipment to show how its increased speed and accuracy is utilized by the engineer in studying the high speed engine.

1. Zero time lag. The diagram on the screen is a picture of the pressures at that instant and is not an average of many cycles.

2. No distortion from heat. The response from pressure is linear from frequencies of 8 to 17,000 c.p.s.

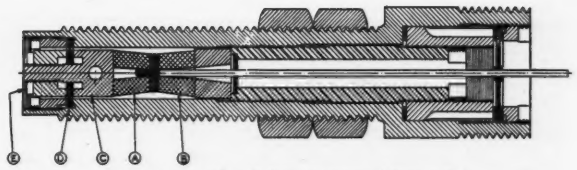


Fig. 3. Details of the pressure pickup unit

Two quartz crystals A and B are mounted so that their positive charges are collected additively on the high potential electrode mounted between their inner faces. The shell serves as a common ground. The crystals are locked securely under an initial pressure between the retainer and a supporting column attached to the diaphragm D. Pressures are transmitted up through the column to the crystals. The diaphragm is shielded from the direct flame heat by the protecting column E which maintains a uniform diaphragm temperature even though the temperature of the gases in the cylinder may change from 100 to 3000 deg. F. during a cycle. Since none of the parts move, errors from inertia common to mechanical indicators are eliminated. The mounting also eliminates connecting passageway errors.

3. Simple electrical calibration of any pressure at any point in the cycle. The error should not exceed plus or minus 2 per cent.

4. The location of all pressure phenomena with respect to any reference point can be determined within plus or minus 1 deg.

5. Pressure-time cards can be converted very easily to rate-of-pressure-time diagrams with very little distortion in amplitude or phase for frequencies up to at least 5000 c.p.c.

6. Through suitable mountings any quartz crystal pickup unit can be used to register almost any varying pressure phenomena in addition to cylinder pressures.

In studying these high frequency wave phenomena which result from combustion, as in Fig. 4, the subject of knock and its relationship to these waves immediately introduces itself. The problem of knock can be subdivided into two problems, namely: what causes it and how can it be measured? The more recent theories contend that these waves are sound waves, the frequency of which depends on the shape and volume of the combustion chamber and also on the density and pressure of the charge. These waves are said to be created by the pressure disturbance caused by combustion and once combustion has ceased the frequency and amplitude of these waves will follow certain

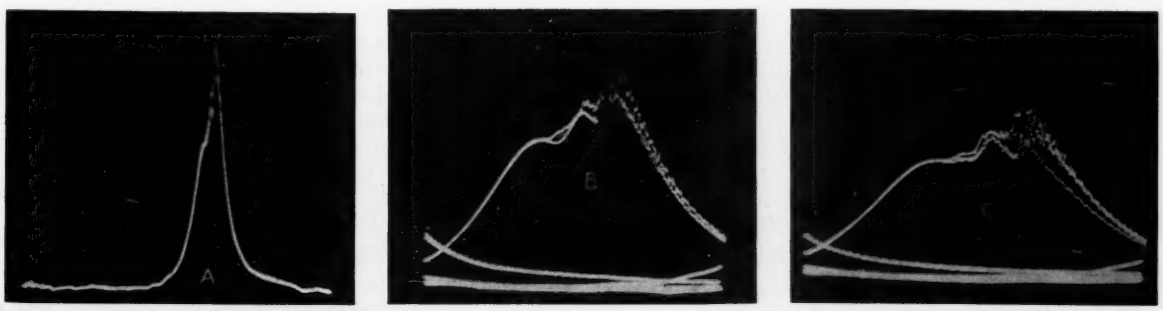


Fig. 4. Pressure-time traces from the main combustion chamber for one complete cycle.

In A the engine was operating at 90 b.m.e.p., 1600 r.p.m. with injection timing set at 33.2 deg. b.t.d.c. This oscillogram of 720 deg. shows all four phases of the cycle: exhaust, intake, compression and expansion, the sharp break at the end of the expansion stroke indicating the point where the exhaust valve opens. To study the combustion process with greater accuracy, the sweep frequency can be raised so that the electron beam will traverse the screen horizontally at a higher speed. B illustrates this point. The complete cycle is still shown but in this particular instance each sweep represents 120 deg. of the cycle. This is the same engine with the fuel injection slightly retarded from the maximum power position. An extremely retarded injection produces a pressure-time oscillogram as illustrated by C. From these oscillograms it can be seen that although each compression is exactly alike no two combustion processes are identical. In every case combustion proceeds in two distinct phases, the second phase for these load conditions being longer and showing a greater rate-of-pressure rise. Combustion is always accompanied by a violent high frequency pressure disturbance in the cylinder. A more detailed picture of this peak pressure period is given by Fig. 5.

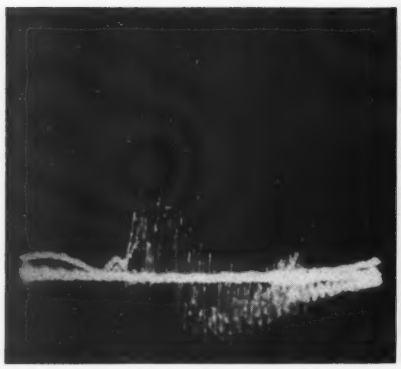
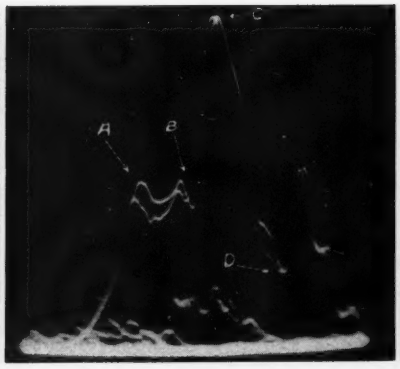


Fig. 5. A rate-of-change-of-pressure-time oscillogram

Each sweep represents 120 deg. of the cycle. Several cycles are superimposed and it is clear that the difference in the combustion process noted on the previous pressure-time oscillograms are in a sense magnified several times. Note the variation of the several cycles. An average would be only a vague approximation. Also, where burning of fuel occurs in two or more stages, it is impossible to associate "knock" to the rate-of-pressure rise in any particular stages. It is the opinion of the writer that the rate-of-pressure card is not entirely suitable for studying combustion even though excessively high rate-of-pressure rises may be responsible for "knock."



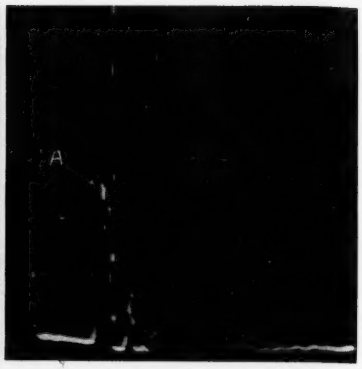


Fig. 6. Pressure-time diagrams showing conditions in the fuel system and the rapidity with which pressure surges are damped

Left, a typical 60 deg. diagram showing the pressures in a Bosch pintle nozzle (DN-12-SD-12) being supplied with fuel from a 9 mm. standard cam Bosch pump. Two consecutive cycles are shown. Although it is clear that no two injections are identical, both cycles follow rather closely the same general pattern. However, these slight differences probably account for the small variations in the combustion processes visible in Fig. 4. Point A of this diagram is the nozzle valve opening pressure which was set for 1600 lb. per sq. in. The fairly constant pressure between points A and B is the result of the additional volume in the fuel nozzle created by the valve being snapped off its seat. The high rate of pressure rise to point C is approximately 600 lb. per sq. in. per deg. Point D is the valve closing pressure.

By adjusting the horizontal sweep frequency to represent 720 deg. or one complete cycle the pressure waves in the fuel line can be studied. The fuel line pressure surges are shown at the right. From this it is clear that the peak pressure of the second pressure wave does not reach the nozzle valve opening pressure indicated by point A. It is clear that the surge pressures are rapidly damped out to become practically zero when the cycles repeat themselves.

definite laws of physics. On account of the complex shape of the combustion chamber of the test engine, only approximate calculations of these frequencies could be made, but experimental results seem to indicate that this theory is true.

Soon after the existence of the phenomena of "knock" was recognized, attempts were made to measure its intensity. Since the investigation of knock conditions in the cylinder presents some difficult problems, the earlier efforts were directed toward measuring the amount of the initial disturbance; that is, the rate-of-change-of-pressure rise through some external apparatus. The fact that these methods are entirely unsuitable for studying knock in the more complex combustion systems can be recognized from Fig. 5.

In carrying out an investigation of the combustion process, it was noticed that the timing of the fuel injection had a definite effect on the amplitude of these high frequency waves illustrated previously by the pressure-time diagrams. Recently, attempts were made to analyze these waves by means of a band pass amplifier. An investigation within the 120 to 2200 c.p.s. range revealed certain pertinent facts about knock and combustion in Diesels. First, the wave form for all harmonics is sinusoidal and the rate of decay of the wave amplitude increases with high frequencies. Second, increases in knock intensity made by advancing the fuel injection affected the wave amplitude of certain frequencies more than others.

Another application of the cathode ray indicating equipment is in the investigation of fuel line pressure phenomena. By mounting the pressure pickup unit in a special adapter near the fuel nozzle both injection and surge pressures can be accurately measured and timed as shown by Fig. 6.

Effects of excessive vibration annoyances on the human nervous system are recognized universally and therefore it is essential to have an accurate means of analyzing these aggravating vibrations. Fortunately, in addition to combustion and fuel line pressure studies, the cathode ray oscillograph can be used to investigate the vibrations of the various parts of an engine if a suitable pickup unit is used.

From the data presented it is clear that the electrical indicator can be of an inestimable value to engineers. Although the uses of the cathode ray oscillograph in engine indication have been illustrated only in a very general way, there is sufficient evidence to show that this indicator can be used with confidence to solve our most difficult pressure and vibration problems. Plans are under consideration at the present time to extend the use of the cathode ray oscillograph in engine studies to include pressure-volume diagrams and torsional vibration phenomena.

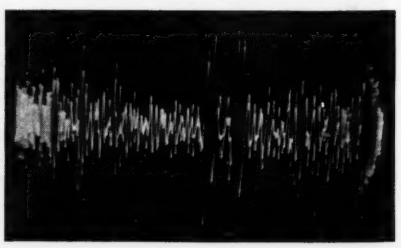


Fig. 7. Frequencies of the cylinder head (left) and crank case (right) determined by means of the vibration pickup unit shown in the author's hand in Fig. 1. In each case the sweep represents 720 deg., the sweep frequency being 8.3 c.p.s. Natural frequencies of the cylinder head and crank case are 1050 and 825 cycles, respectively

Sulphur from Flue Gases?

FROM DISCUSSION which has been going on in this magazine over a period of several months, it is evident that the removal of sulphur dioxide from flue gases is possible. There is, however, considerable difference of opinion as to its practicability, differences of opinion which revolve around the question of whether the gases so recovered can be used in making by-product sulphuric acid or sulphur which could compete on a price basis with the present commercial products.

Without this by-product recovery the cost of gas removal is considered by power plant engineers to be prohibitive. Two English Stations have been washing flue gas for some time without trying to recover the sulphur. Prof. A. G. Christie, President of the A.S.M.E., in a recent address said that at Battersea Station the washing was costing 37 ct. per t. for 0.87 per cent sulphur coal. In this case the wash water is dumped directly in the river without neutralizing and as the gases are sent to the stack at a temperature of 90 deg. F. there is a considerable increase in induced draft fan power.

At Fullham Station detailed costs are not available but it is probably running around 60 ct. per t. with 0.91 per cent sulphur coal. In this case the wash water must be neutralized and the neutralizing building is almost as large as the power plant itself. In addition the resulting sludge has to be taken out to sea in barges and dumped.

In this country, especially in the middle west, the sulphur content of coals range up to 3, 4 and even 5 per cent which would increase the cost of gas washing for SO_2 removal to a point perhaps equal to or even above the cost of coal.

Proponents of gas washing base their argument primarily upon the recovery of the sulphur as a by-product. In this connection the remarks of Dr. Gustav Egloff in a paper "Petroleum—Its Chemical and Industrial Significance" presented before the Congresso Internazionale di Chimbica at Rome is of interest. Dr. Egloff said that the oil industry is the second largest user of sulphuric acid in the United States and during 1936, used 1,100,000 t. of 50 deg. Baumé.

Natural and refinery gases contain hydrogen sulfide from a fraction to over 10 per cent. Several refineries have installed sulphuric acid making plants, using cracked gases containing hydrogen sulfide. This is extracted and then oxidized to 66 deg. Baumé sulphuric acid at the rate of over 75,000 t. a year, which in terms of 50 deg. Baumé acid this is equivalent to 100,000 t. This has replaced other sources of sulphuric acid and the production cost is such that it can compete on an equitable basis with the present sulphuric acid industry based upon elementary sulphur, iron pyrites, roasting of sulfide ores.

In manufacturing the acid, the hydrogen sulfide is burned so that the combustion products contain sulphur dioxide and oxygen in proportions required for catalytic conversion to sulphur trioxide. The sulphur trioxide is absorbed in strong acid in the usual manner. In this conversion 7.640 standard cubic feet of hydrogen sulfide are chemically equivalent to one ton of sulphuric acid. In actual practice the amount is slightly greater due to losses and incomplete conversion of sulphur dioxide to sulphur trioxide. The largest unit converting hydrogen sulfide to sulphuric acid produced 100 t. of 66 deg. Bé acid per day.

What makes this competition particularly serious is the fact that the use of sulphuric acid in the oil industry is definitely decreasing due to the introduction of newer methods of refining such as solvent extraction, anti-oxidants, color inhibitors and dyes. The quantity of acid used in the oil industry in 1936 was 10 per cent or 140,000 t. less than that used in 1932, although during the same period of time the amount of crude oil refined increased from 785,159,000 bbl. to 1,098,516,000 bbl., or 40 per cent.

The large volumes of hydrogen sulfide available for conversion to sulphuric acid will place the oil industry in a position to market its acid outside for other than its own uses for the cost of sulphuric acid from hydrogen sulfide is materially less than from other sources. The oil industry can produce more sulphuric acid from the hydrogen sulfide potentially available in natural gas, crude oil and refinery gases than the whole requirement of the United States.

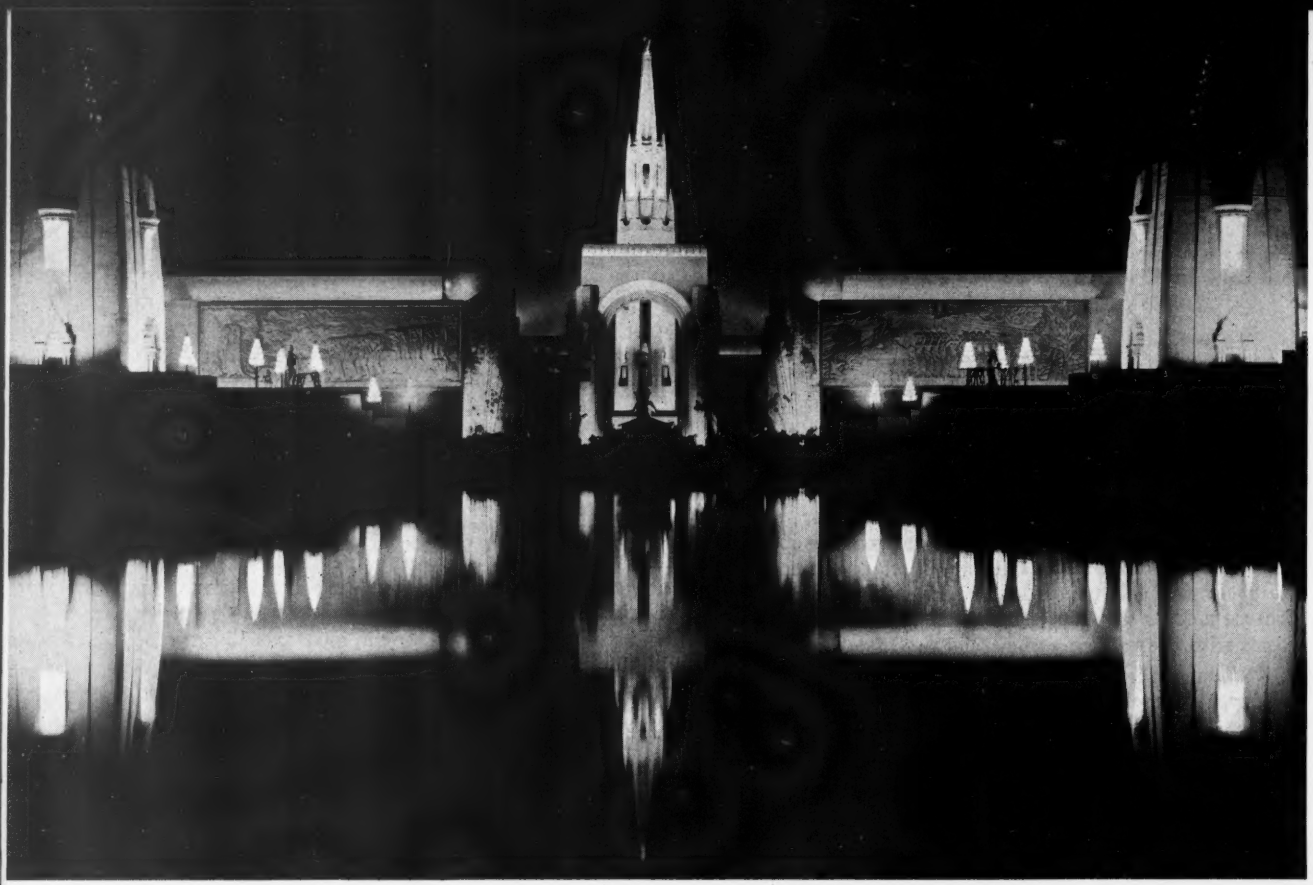
Air Heater and Economizer Selection

Continued from page 303

mately as the 2/3 power of the gas velocity, whereas the draft loss increases as the square of the velocity, it is quite apparent that a balance between fan power and transfer rate is reached beyond which point there is no advantage in attempting to increase the transfer rate.

In an economizer, draft loss is a factor obtained only on the gas side, since the feedwater is driven through the economizer by means of the feed pump with negligible power requirements. The air heater, however, requires fans to draft both the gas and air side, which is an additional point to be considered in air heater selection. Further cost considerations for air heaters include the hot air duct from the fan to the burner or stoker and the insulation on this duct to prevent excessive radiation loss before the air reaches the combustion chamber.

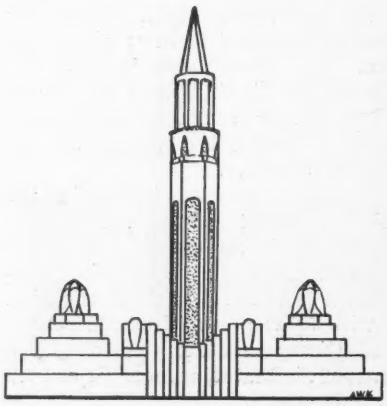
The preceding fundamental factors influencing the design and selection of heat traps are purely theoretical. However, theory is an excellent catalytic agent to assure proper union of the practical considerations which in the end determine the final choice. Part II will deal with these practical considerations applied with sound theory in order to arrive at a satisfactory selection of air heater, economizer or both for maximum economic return.



Above: The twin towers of the East and the Tower of the Sun reflected in the Lake of the Nations

Right: The South Tower in The Court of the Moon

On opposite page: Tower of the Sun reflected in the Fountain of Western Waters



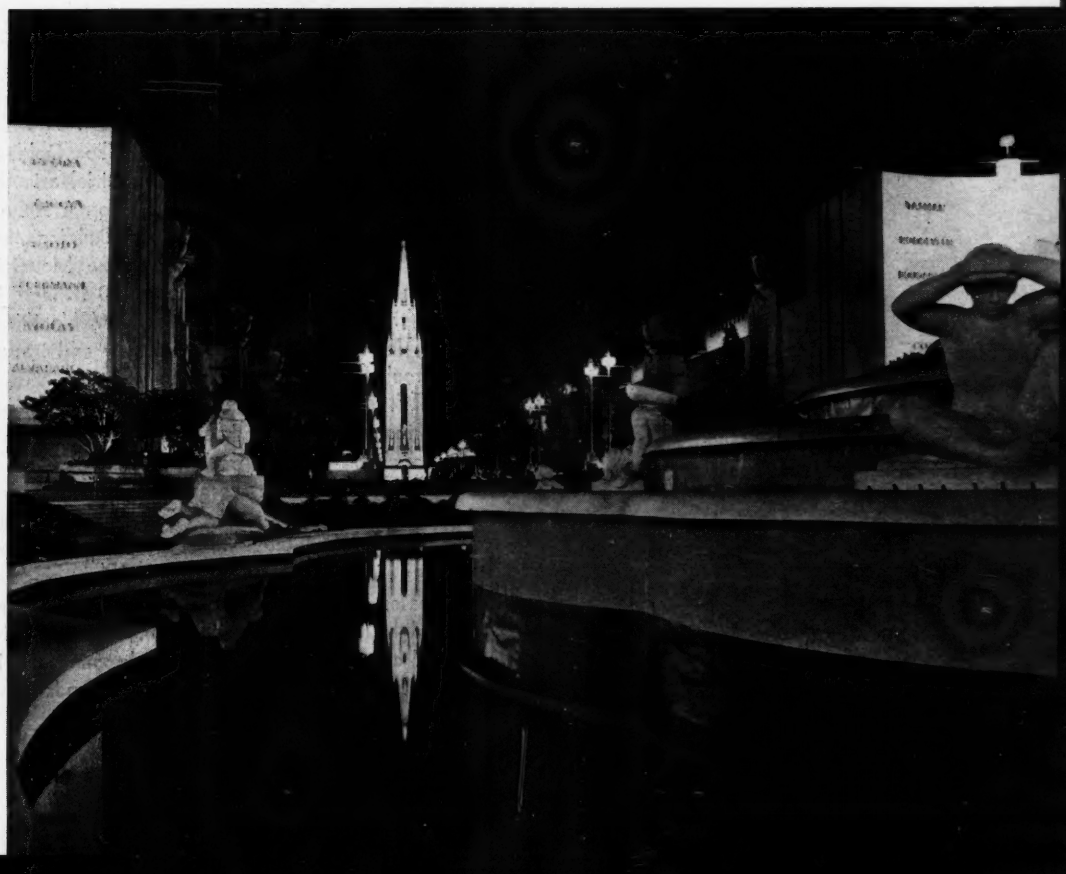
LIGHT Glorifies The Golden Gate Exposition

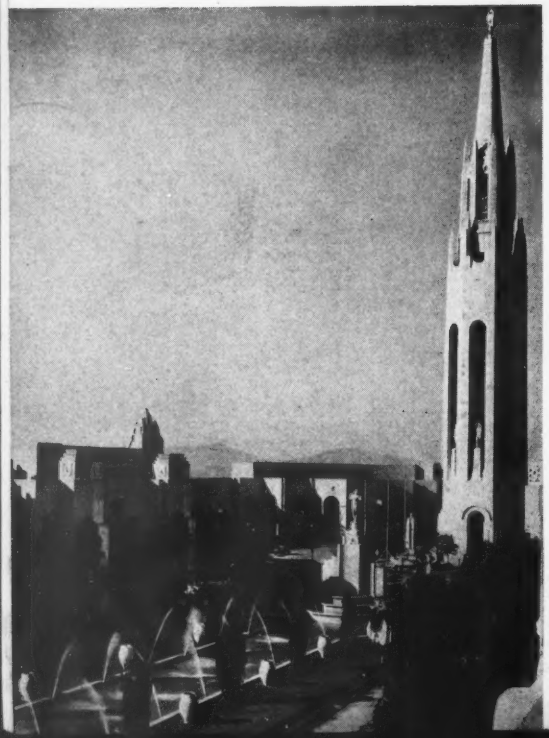
WHATEVER ELSE the Golden Gate International Exposition at San Francisco has to offer, the one thing it possesses above everything else is beauty. Seen at night, glowing with brilliant radiance, it seems to float on the black velvet waters of San Francisco Bay—a dream city that might have been lifted bodily from the pages of the Arabian Nights.

And if names constitute a criterion, its external loveliness attests the beauty of its internal plan. Court of the Moon; Tower of the Sun; Fountain of Western Waters; Statue of the Evening Star—what names these? Surely these intriguing names did not arise from motives even remotely connected with commercialism; they bespeak romance, reverie and fancy.

Surrounded by the shimmering waters of San Francisco Bay, the Exposition is beautiful by day but it rises to the full height of its loveliness at night when the dazzling brilliance of thousands of lamps comes into being. The pictures presented here, lovely as they are, only do poor justice to the actual scene.

No expense was spared to make the illumination of the Western World's Fair magnificent. From a thousand sources, light of many hues bathe the whole island in a radiant glow. The play of color embraces the entire gamut of spectral colors—off-whites, amber, yellow, green, magenta, gold, peach, pink, blue and red—each court being held to two or three harmonious hues.





The illumination is almost entirely indirect and is confined largely to the surfaces of the buildings and architectural structures. When lighted at all, trees are shown up in a rich green but, more often, they appear merely as dark masses against glowing backgrounds. The illumination was done under the direction of A. F. Dickerson of the General Electric Co.

The Fair is essentially "Pacific" in character, that is, the forms tend to reflect the architecture of the Pacific Nations; hence the great Elephant Towers flanking the Portals of the Pacific at the main entrance. These towers rise to a height of a 12 story building. From the far east come also the Towers of the East overlooking the Lake of Nations. These are reminiscent of Burmese Temples. The Court of Reflections is set off by lighting elements modeled along the lines of Siamese ceremonial umbrellas, 50 ft. high, their translucent tops fashioned of flexible fabric. Among the unique lighting fixtures evolved were huge cylindrical lanterns, 86 ft. high, fashioned of glyptal-impregnated canvas.

Another novel feature of the illumination lies in the character of the wall surfaces. By literally turning the buildings "inside out" and using a mica impregnated surface finish, the exposition stylists developed surfaces that glitter with millions of gem-like sparkles.

Aside from its esthetic values, the Golden Gate Exposition has many features of interest. The industrial arts and the sciences are well represented. The University of California alone has a $250,000 exhibit. In the Mines, Metals and Machinery Building, the complete story of mining is told. In this exhibit, "Treasure Mountain" is a replica of the western mining country, stretching 160 ft. long, 85 ft. wide and rising to a height of 50 ft. above the floor. Within this mountain are replicas of mines, full size tunnels with machinery and transportation systems just as one would see them in an actual mine.

In the Hall of Science, one of the principal points of interest for those technically inclined, exposition visitors are able to look behind the scenes of some of the world's most famous laboratories. Here some 20 American and foreign research laboratories demonstrate recent progress in the various sciences. Here a chemical "3 ringed circus" offers unusual entertainment in simplifying chemical phenomena for the public. How millions of dollars worth of chemicals are made each year from common salt-water brine from dead lakes and the oceans is shown in an exhibit staged by the Dow Chemical Co. In 5 separate displays the important use of chemicals are shown—how bromine and iodine are used in medicine, photography, in anti-knock compounds for automobile engines, how

magnesium-alloys are used in airplanes and streamlined trains to reduce weight and add strength.

The marvels of chemical farming are presented by the Plant Nutrition Division of the University of California. In a special structure within the Science Building plants are grown in glass jars filled with chemical solutions. The lighting in this exhibit makes use of the new fluorescent lumiline units.

To demonstrate progress in acoustics, the University of California has constructed a special acoustical test room, with walls having rotating panels to show the acoustic effect of various surfaces.

A novel feature of the U. S. Steel Corp. exhibit are the two replicas of the Bay Bridge towers, 1/13 actual size and built with such fidelity that even the rivet heads, both in number and position, match those in the towers of the bridge itself.

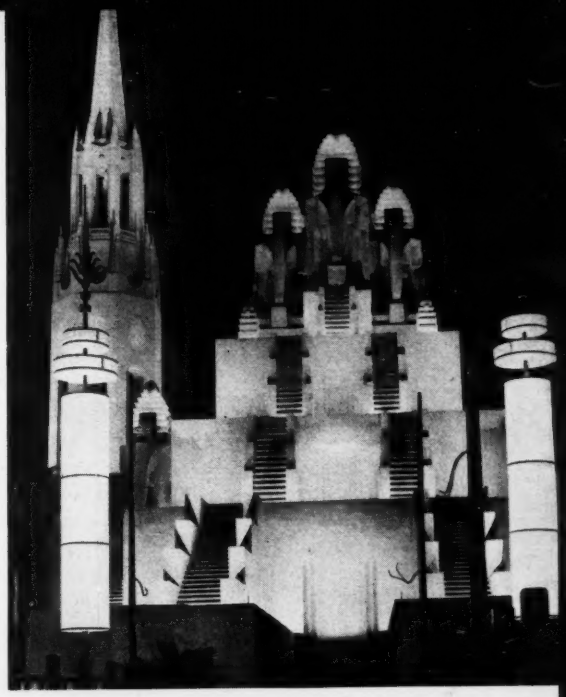
Another part of the U. S. Steel display is a diorama showing how the city of San Francisco might look through the eyes of the citizen of 1999.

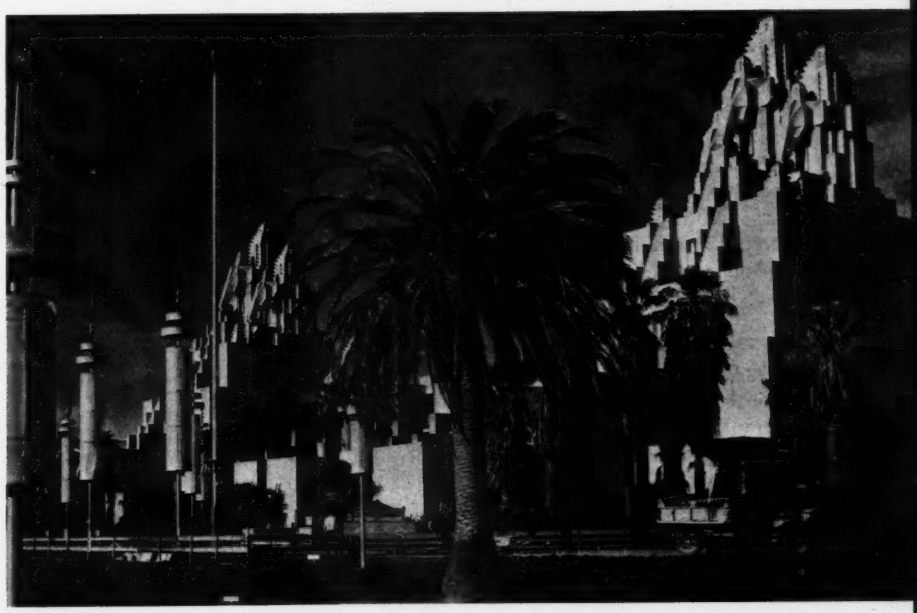
Among the unusual aspects of the exterior illumination system is the use of so-called "black light" with fluorescent paint to achieve the effect of movement and high color vitality on panels, murals and pieces of sculpture. "Black" lighting is supplied by mercury lamps with special purple bulbs that transmit only the ultraviolet light. This type of lighting is employed in 16 architectural niches in the Court of the Seven Seas.

The interiors of the buildings are uniformly lighted by day and night with no windows to mar the planned effectiveness of the displays.

The total illumination of the 400 acre island will consume an estimated 40 million kilowatt-hours of energy throughout the 288 days of the Fair. Power is supplied by the Pacific Gas and Electric Co. to a 16,000 kv-a. substation on Treasure Island through 3 submarine cables each 9000 ft. long extending from the mainland. These cables operate at 11 kv. At the substation, the energy is stepped down to 4 kv. for distribution throughout the grounds.

The photographs on these two pages are described as follows: Upper left. A view of Treasure Island from Yerba Buena Island. Center left, the main entrance and the flanking Elephant Towers at night. Lower left, the Court of the Moon and the Statue of the Evening Star. Upper right, the Elephant Towers with the Tower of the Sun behind. Center right, the Elephant Towers flanking the Portals of the Pacific. Lower right, one of the twin towers of the East with the bas-relief "The Path of Darkness" by Lulu H. Braghetta.





New High Pressure Plant At

Modern 110,000 lb. per hr. 500 lb. pressure steam generator and 2500 kw. turbine replaces old low pressure plant at Eddy Paper Corp. Mill at White Pigeon, Michigan.

QUESTIONS regarding steam and electric power costs for paper mills should be of paramount interest to officials of any paper company. Under the competitive conditions existing in the paper industry today the cost of power may well determine the difference between profit or loss in the operation of the mill. For this reason all factors which influence power costs must receive careful consideration.

The officials of the Eddy Paper Corporation were fully aware of these facts when the construction of the new power plant described in this article was first considered. Throughout, the most careful attention was given every detail of its design; every modern improvement was considered and the ultimate object, that of providing a highly efficient plant at low cost but consistent with a demand for a high degree of reliability, was never lost sight of.

The old power plant was antiquated. A new plant was readily justified on the basis of savings which would accrue through several years' operation. Because of space conditions the old plant was not suitable for the installation of new equipment, so a complete new building was decided upon. This plant, located on the opposite side of the paper mill was started in October, 1937, and most of the construction carried on in the winter of 1937-38. The engineering was handled by Day and Zimmermann, Inc., John Phillips Badenhausen, Engineer, in co-operation with L. J. Meunier, vice president of Kieckhefer Container Co. A. S. Barker, the co-author was project engineer for the Eddy Paper Corp. James Barnhart is chief operating engineer. Fabrication and erection of the steel work was done by Jarvis Engineering Corp. of Lansing, Mich., and the general contracting by Frank Shoemaker of Sturgis, Mich.

An outstanding feature of the power plant is its compactness. With an area of 60 by 75 ft. and a height of 45 ft., 9 in., careful planning permitted the installation of steam generating capacity of 110,000 lb. per hr. and 3000 kw. of electric generating capacity without crowding; indeed there is ample room around all the equipment.

The building of brick and steel construction is plain and simple architecturally, but of solid construction with ample steel casement windows for lighting and ventilation. To allow for expansion space was provided for a future turbine and the west wall constructed of Robertson corrugated metal siding, permitting the extension of the building for the addition of a future steam generator.

In the preliminary design considerations it was necessary to decide between the installation of a single steam generating unit and two or more smaller units, affording standby capacity. The reliability of present-day steam generators fed with chemically treated water, finally, influenced the decision in favor of a single large unit.

The Steam Generator

The steam generator selected is a 500 lb. pressure, 110,000 lb. per hr. unit, designed and built by Day &

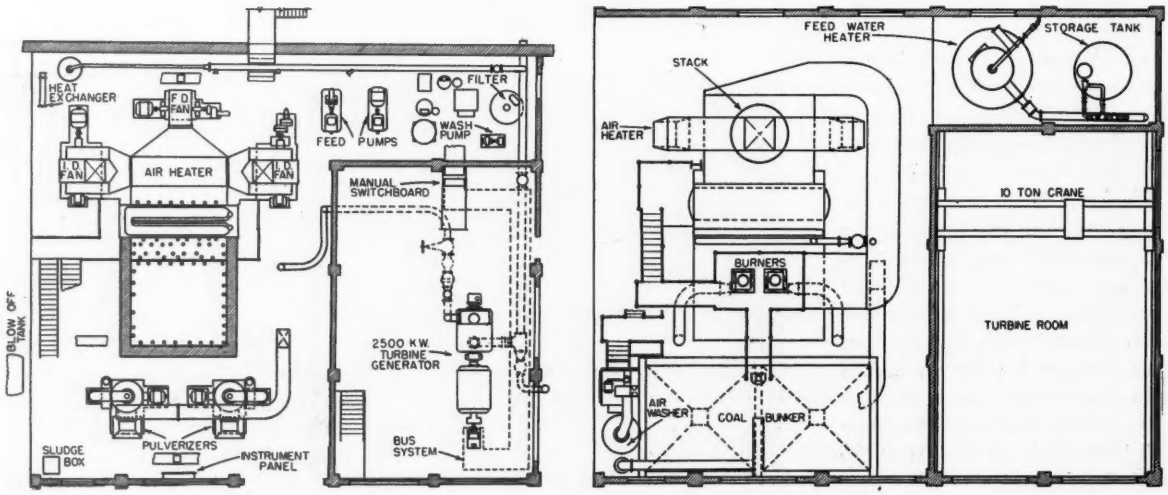


Fig. 1. Plans at two elevations showing the arrangement of equipment

Eddy Paper

BY LLOYD J. WESTIN
Day & Zimmerman, Inc.
and ANDREW S. BARKER
Kieckhefer Container Co.

Zimmermann, Inc., John Phillips Badenhausen, Engineer. It operates at 450 lb., 650 deg. F.

As shown by the accompanying illustrations, the unit consists of a completely water cooled furnace, a boiler section, superheater (combination convention and radiant heat type), economizer, air heater, forced and induced draft fans together with other auxiliaries.

The unit is arranged to use either pulverized bituminous coal or oil. For burning coal two type C-50 Strong & Scott pulverizing mills are provided. The two oil burners are Peabody combination Toronto units, using mechanical atomization. The burners are mounted on top of the furnace for vertical downward firing. Instead of the usual baffle arrangement, the baffle between the furnace and the boiler section is arranged so that all the gases are compelled to pass downward through the furnace. This assures and provides effective turbulence and radiation; it also insures positive ignition by compelling the incoming fuel to pass through the high temperature gas zone at the top of the furnace. The downward flow of the gases is the natural path since the gas continually loses heat by absorption in the water cooled furnace walls.

The furnace is of the dry ash type. All four walls, roof and floor provide effective cooling surfaces so that slagging is almost impossible. The water wall furnace tubes are of the bare type.

Although the furnace was designed for a heat liberation of less than 30,000 B.t.u. per cu. ft. test data indicates that 50,000 B.t.u. per cu. ft. should be easily obtainable. All the steaming tubes are above the normal water level, assuring good steam quality without priming.

Ash is removed from the furnace by hand, periodically, through two louvred doors at the bottom of each side of the furnace. Soot is removed from the economizer and air heater through gas tight doors at the bottom of these sections and is also done, periodically, by hand.

The steam generator constitutes an extremely compact unit, requiring an overall space including fans and auxiliary equipment, of only 17 ft. 5 in. wide, 38 ft. 8 in. deep and 35 ft. up at the firing platform on top of the boiler. To obtain this low height, the convection boiler section is built behind the furnace. A relatively small amount of boiler heating surface is provided, being supplanted by the surface in the economizer and air heater which is more effective and efficient. The stack is 150 ft. high, of self supported steel construction and mounted above the back of the steam generator.

The entire unit was designed to incorporate simplicity and economy of construction without sacrificing quality. It will be noted that all feeders and relief connections to the water walls are contained inside the furnace, providing a neat outward appearance.

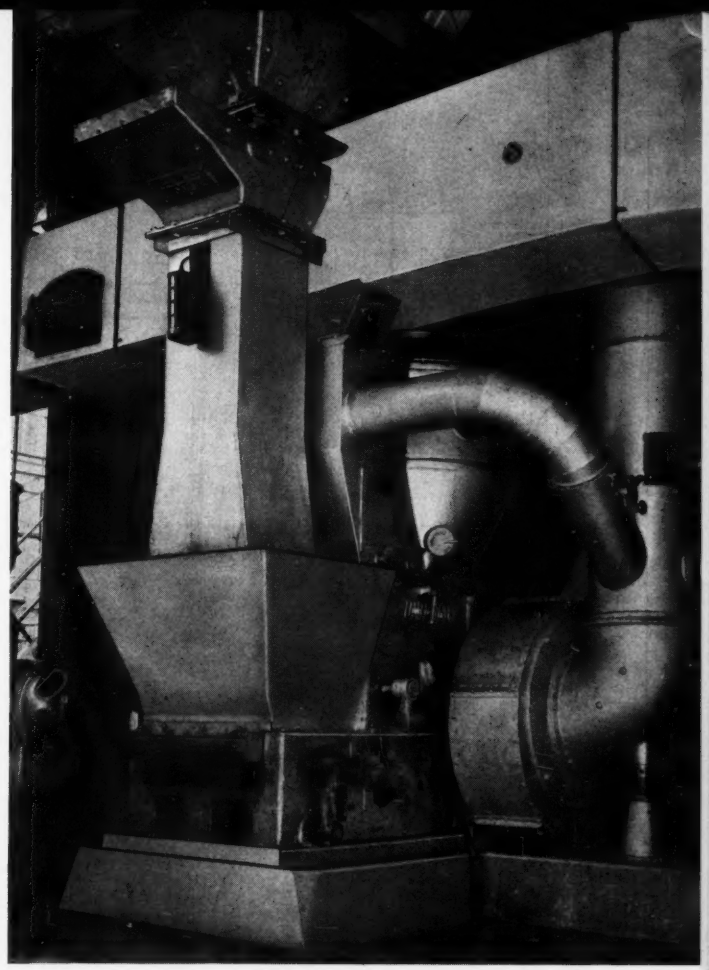


Fig. 2. One of the two pulverizing units

The combination connection and radiant heat type of superheater insures an even superheat over wide variations in load, a feature of particular importance in industrial installations where such load conditions prevail. The tubes of the superheater are hung from two steam headers mounted outside and on top of the furnace. This makes installation and maintenance simple.

The roof section of the steam generator is supported from structural steel beams above the furnace. Since there is no weight on any of the roof tubes from this roof section, the tubes are free to expand or contract. This type of construction assures that the original installation and all repairs of any part of the roof can be made from the top of the furnace.

Both forced and induced draft fans are on the ground floor. To insure continuity of service two induced draft fans are used, one at each side of the unit at the rear. Either fan is of ample capacity for full load operation but only one is operated at a time. One of these units is turbine driven, the other motor driven.

The forced draft fan not being subject to so much wear, only a single unit is installed. This, however, is provided with dual drive, a turbine at one end and a motor at the other with disconnecting couplings so that

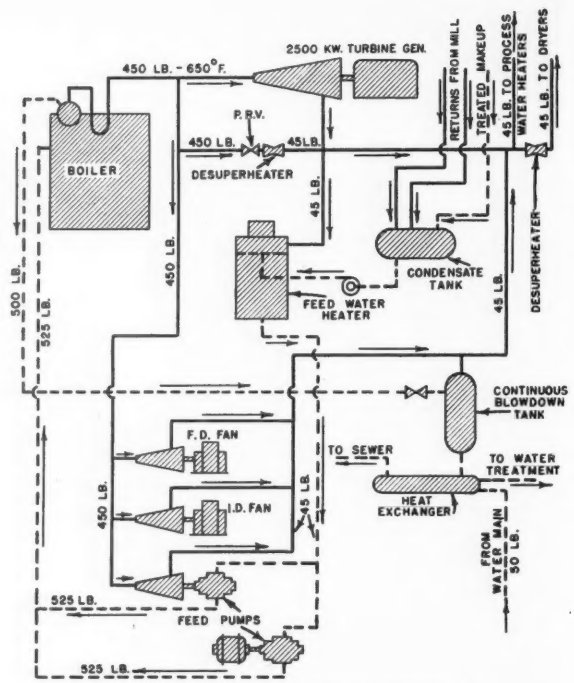


Fig. 3. Flow diagram showing steam and water lines

either drive may be used. This provides both continuity of service and flexibility in adjusting the heat balance of the station.

Combustion Control

Control of combustion is effected automatically by an electrically actuated system furnished by the Brooke Engineering Co., Inc. Two regulators responsive to steam pressure variations constitute the primary elements in this system, one controlling secondary air and the other the coal feed dampers on both of the mills. These regulators are adjusted to keep in accurate step with each other. The fuel-air-ratio is substantially constant throughout a load range of 3 to 1 as indicated by the pens of the Bailey meter. Furnace draft is maintained constant by a separate regulator controlling the boiler outlet damper. A fourth regulator is used to control air pressure at the burner.

A pressure operated switch was also furnished with pressure connection between the induced draft fan and the boiler damper. In the event of failure of the induced draft fan, this switch automatically closes, tripping the control switch of the pulverizers and shutting down the pulverizers.

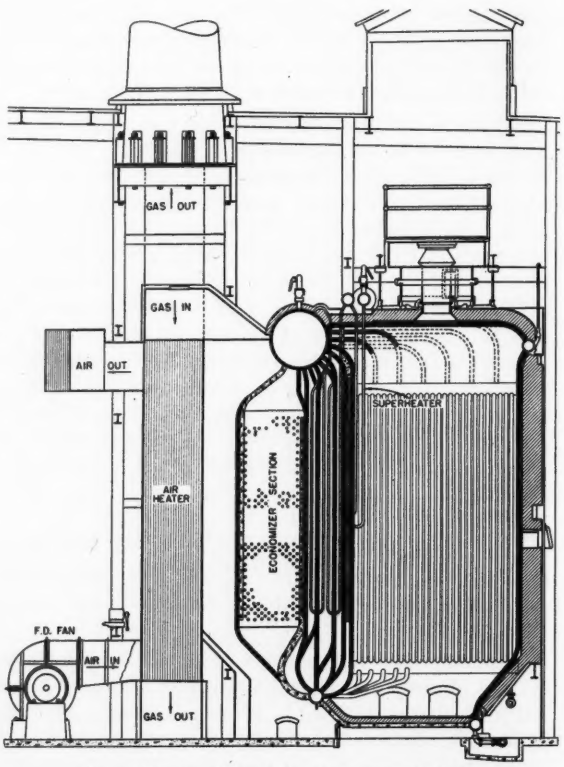


Fig. 5. Section through the steam generator unit

Remote hand control switches were furnished for each regulator. Each switch includes red and green indicating lights telling the operator that:

(1) Current is on the regulator,
(2) That the regulator is in balance,
(3) If unbalanced in which direction it is moving,
(4) How fast it is moving,
(5) When it has reached either open or shut limit.

These lights have proved to be of considerable assistance to the operating personnel.

No difficulty has been experienced in maintaining close steam pressure regulation and high efficiency

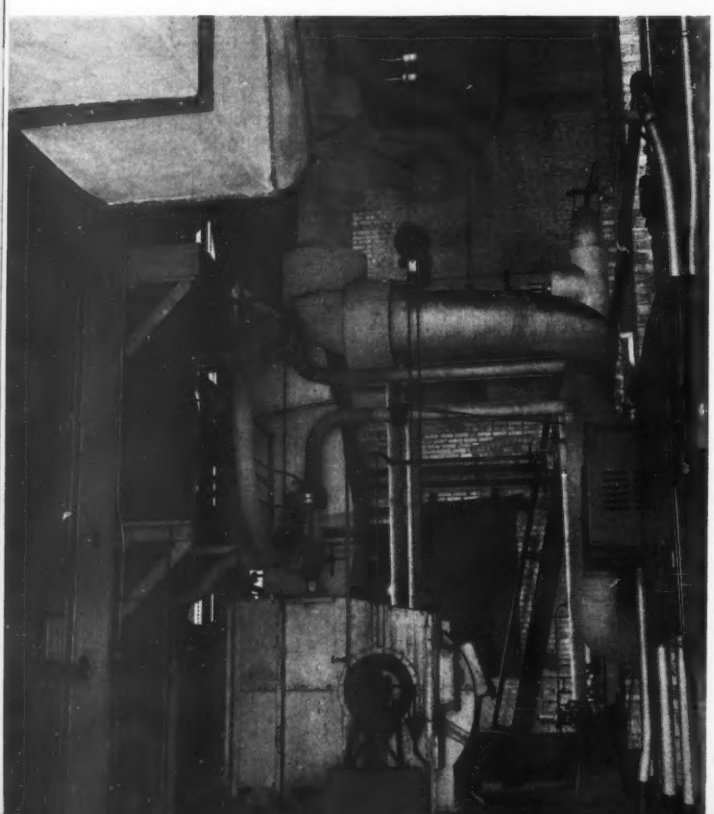


Fig. 4. A view at the rear of the boiler

PRINCIPAL EQUIPMENT AT EDDY PAPER CORP.

GENERAL

COMPANY: The Eddy Paper Corp.
LOCATION: White Pigeon, Mich.
DESIGNERS: Day & Zimmermann, Inc., John Phillips Badenhausen, Engineer.
GENERAL CONTRACTING: Frank Shoemaker, Sturgis, Mich.
STRUCTURAL STEEL: Fabrication and erection, Jarvis Engineering Co., Lansing, Mich.
BOILER SETTING: O. H. Warwick Co.

STEAM GENERATING EQUIPMENT AND AUXILIARIES

STEAM GENERATOR: John Phillips Badenhausen integral furnace, type VF-1; combination coal and oil (normal operation, pulverized coal) with water walls, superheater, economizer, air heater, soot blowers and fans. Boiler design pressure 500 lb. per sq. in. gage; rated capacity 110,000 lb. per hr.

AIR HEATER: John Phillips Badenhausen, single pass, internal gas, tubular type, 14,180 sq. ft. heating surface.

ECONOMIZER: John Phillips Badenhausen horizontal transverse flow, bare tube type.

SUPERHEATER: John Phillips Badenhausen combination convection and radiant type. Convection element, steel tubes. Radiant heat elements of alloy steel known as "Sicromel No. 5" made by Timken.

PULVERIZERS: Two, Strong-Scott, type C-50 Uniflow type, driven by 75 hp., Westinghouse Electric & Mfg. Co. squirrel cage motors. Rated capacity 5250 lb. per hr. with low grade Illinois and Indiana coal. Supplied by Strong Scott Co

BURNERS: Two, type H-23 combination pulverized coal and oil, supplied by Peabody Engineering Co.

IGNITION OIL PUMP: Geo. D. Roper Corp., driven by 2 hp. G. E. motor.

FORCED DRAFT FAN: B. F. Sturtevant Co. —Size No. 85 Turbovane, design No. 8. Class No. 3—DWDI shaft extended both ends. One end connected to 75 hp. Westinghouse type CS squirrel cage motor, 1750 r.p.m., 3 phase, 60 cycle, 440 v. Other end connected to Westinghouse type C-14 turbine with integral reduction gears—450 lb., 750 deg. F. to 45 lb. back pressure, turbine speed 4500 r.p.m., gear speed 1750 r.p.m.

INDUCED DRAFT FAN: B. F. Sturtevant Co. —2, size No. 1000 Turbovane DWDS—1 direct connected to 125 hp. Westinghouse type CS squirrel cage motor, 3 phase, 60 cycle, 440 V, 1160 r.p.m. 1 direct connected to Westinghouse Type C-14 turbine with integral reduction gear, 450 lb., 750 deg. F. to 45 lb. back pressure, turbine speed 4500 r.p.m. gear speed 1160 r.p.m.

BOILER METERS, INSTRUMENTS AND ACCESSORIES

BOILER METER: Bailey Meter Co.—2 pen recording air flow, steam flow.

WATER COLUMN AND GAGE GLASS: Wright Austin Co.

DRAFT GAUGES: 6 point, Ellison Draft Gage Co.

CO_2 METER: Hays Corporation—Indicating recording type with a large dial easily visible, mounted on control board.

THERMOMETER: 1 Brown Instrument Co. No. 6482, two pen recording thermometer giving feedwater temperature and boiler exit gas temperature.

COAL METERS: Bailey Meter Co.—2 Type V-6 Bailey Coal Meters.

HAZE GAUGE: Electric eye supplied by Ess Instrument Co.

COAL GATES: Stock Engineering Co.

SOOT BLOWERS: Supplied by Bayer Co., consisting of 2 HT elements and 2 extra heavy chrome clad elements.

COMBUSTION CONTROL

AUTOMATIC COMBUSTION CONTROL: Brooke Engineering Co.—Electric type. 2 steam pressure regulators, 1 coal feed and 1 secondary combustion air, covers 3-1 range. 1 Furnace draft regulator controlling outlet damper. 1 air pressure regulator at burner, has interlocking connection between induced draft fan to trip pulverizers, shutting them down if fan goes down. Red and green indicating lights are furnished with control to give indication of how control is working.

COAL HANDLING

COAL CONVEYING EQUIPMENT: Brady Conveyors Corp., Chicago—Pneumatic pressure type driven by Roots-Connersville Blower handling 25 tons per hour. Coal drops from cars to hopper into pressure feed and is blown approximately 800 ft.

FEEDWATER EQUIPMENT

BOILER FEED PUMPS: Two Pennsylvania Pump and Compressor Co.—2½ in. four stage type OMSB, rated capacity 110,000 lb. per hr. at 292 deg. F. 1 pump direct connected to 125 hp. Westinghouse squirrel cage CS motor, 3 phase, 60 cycle, 440 v., 3550 r.p.m., and 1 direct connected to 125 hp. Westinghouse type C-14 turbine, 3500 r.p.m., 450 lb.; 750 deg. F. to 45 lb. back pressure.

FEEDWATER REGULATORS AND PUMP GOVERNORS: Copes, supplied by Northern Equipment Co., Erie, Pa.—Regulator "flowmatic" type operates from steam flow and water level. Steam flow is measured by taking drop across superheater and water level by Copes thermostat. Copes differential boiler feed pump governors. Motor driven pump SDS-2 differential pressure type valve maintaining a fixed excess pressure in feed line over boiler drum pressure. Acts as differential pressure inducing valve installed in pump discharge. Turbine-driven pump SDS-2 differential pressure governor installed on steam line to turbine, controlling pump discharge pressure by varying turbine speed.

WATER SYSTEM AND CONTINUOUS BLOW DOWN: Hot process lime and soda ash, blow down, continuous, heat recovery type, both supplied by International Filter Co.

FEEDWATER HEATER: Worthington deaerating vertical single shell type, 50 lb. pressure 0-oxygen 290 deg. F. at 45 lb. pressure, nonmetering with accessories capacity 110,000 lb. per hr.

BOILER FEEDWATER CONSULTING SUPERVISORY SERVICE: W. H. & L. D. Betz Chemical Engineers of Philadelphia, Pa. Copies of plant tests are analyzed weekly and a complete set of samples from all points in the boiler system are analyzed monthly.

GENERATING EQUIPMENT

TURBINE GENERATOR: General Electric Co. —1 2500-kw. non-condensing, with direct connected exciter. Generator good for 3125 kv-a., 3600 r.p.m., 2 pole, 3 phase, 60 cycle, 480 v. Initial steam pressure 400 lb. gage, 650 deg. F. temperature good for ultimate of 750 deg. F. back pressure 45 lb. exciter direct connected 125 v. d.c., 25 kw. compound wound, unit supplied with air and oil cooler.

PRESSURE REDUCING AND DESUPERHEATING STATION: Supplied by Swartwout, consisting of one 12 in. Venturi type desuperheater, one ½ in. type CS water regulator valve, 1 type thermo master control, 35,000 lb. per hr., initial 45 lb., 350 deg. F. final to 45 lb. saturated; one 3 in. desuperheater, 1½ in. type CS water regulator valve; 1 type thermo master control, 14,000 lb. per hr. initial, 400 lb. 725 deg. F. to final 45 lb. 350 deg. F.

BACK PRESSURE VALVES: Cochrane Corp. —Multiport type.

SWITCHBOARD: General Electric Co.—Dead front type.

AUXILIARY MOTORS CONTROL AND TURBINES: Westinghouse Electric & Mfg. Co.

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within a load range of 3 to 1, even though sudden swings are occasionally experienced. The system is very quick and positive in its operation and does not "hunt."

COAL HANDLING

After selection of the steam generator unit, the next problem to settle was coal handling and conveying equipment. Because the new power plant was located on the opposite side of the paper mill from the old plant, it was a long distance from the existing coal storage and railroad siding. To change the railroad siding and coal storage facilities to the new location. or to use a continuous belt type conveying system would have been expensive. The only inexpensive logical alternative was a pneumatic coal conveying system. Upon investigation this type of conveying system seemed to be very reliable, simple, inexpensive and quite trouble free. After due consideration from all angles a Brady Pneumatic system was chosen. The coal is discharged from cars into a track hopper. This feeds the coal blower which blows the coal through a pipe line to the coal bunker about 800 ft. distant.

The coal after being transported pneumatically is discharged into an air tight steel bunker directly above the two pulverizers in front of the steam generator unit. The air required for transporting the coal is exhausted from the bunker by means of a cyclone type exhauster. The exhauster recovers any particles of coal that may be carried off in suspension, before the air is discharged to the atmosphere above the roof.

ELECTRIC GENERATING EQUIPMENT

Electrical energy is produced by a 2500 kw., 480 v., 80 per cent p. f., 3 phase, 60 cycle alternator with a direct connected exciter, driven by a 450 lb., 750 deg. back pressure turbine. This unit, supplied by General Electric Co., operates at 3600 r.p.m. and exhausts at 45 lb. All steam passing through this turbine is used for process work in the mill. Current is distributed throughout the mill at the generated voltage, 480 v. A two panel General Electric switchboard is provided with recording voltmeter, voltage regulator and a 4000 amp. air circuit breaker. The generator is equipped with an Andale oil cooler and a G. E. air cooler.

An essential feature of the steam system is the Swartwout Reducing Valve and Desuperheater provided to always by-pass a small amount of steam around the turbine. This arrangement, shown in the flow diagram, Fig. 3 makes it possible to maintain the back pressure of less than 45 lb. at all times, thus preventing process steam from being discharged at the atmosphere. A Cochrane multiport back pressure valve is also provided in the turbine exhaust.

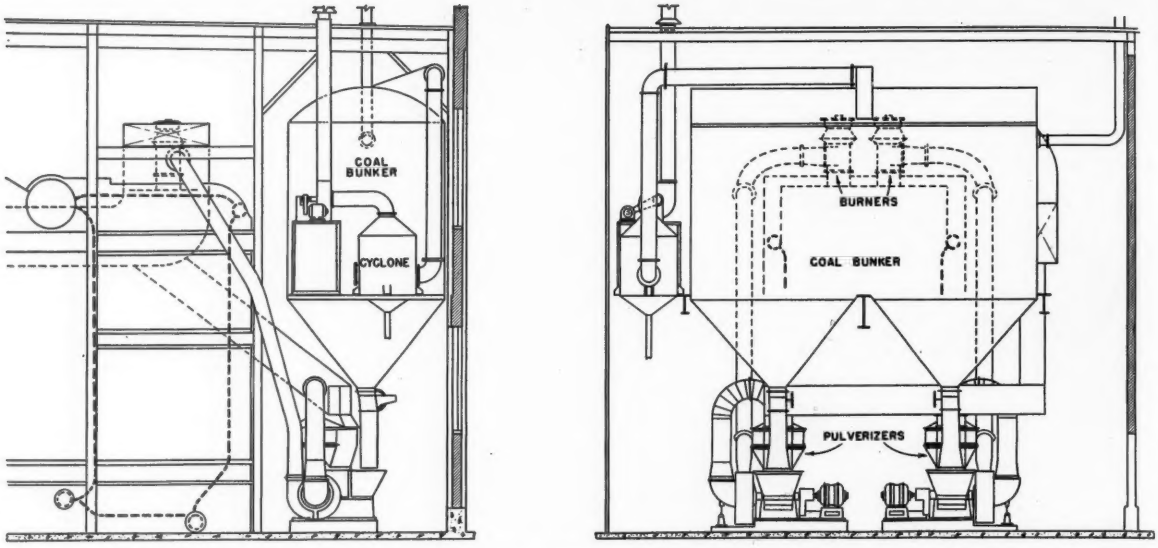


Fig. 6. Elevations showing the arrangement of the pulverizers and burners

Feedwater Supply

Raw water for boiler feed is obtained from a nearby creek the total hardness of which varies between 270 and 320 p.p.m., the greater part of which exists in the carbonate form. This water is first treated with lime and soda ash in a hot process International Filter Co. softener. The softened water is filtered through a bed of anthracite coal thereby eliminating pickup of silica from the filter medium. Softened water and returned condensate are mixed in the main condensate tank with a float control governing the admission of softened water to this tank.

The mixture of softened water and returned condensate is then pumped to a Worthington deaerating heater mounted 25 ft. above the floor level to give sufficient head for the feed pumps. An arrangement was made so that sodium sulphite can be fed to the feed pumps to neutralize the effect of any oxygen that may be present. The internal precipitation of the incrusting salts present in the boiler water is accomplished by the introduction of di-sodium phosphate directly into the boiler drum.

There are two boiler feed pumps, each capable of carrying the boiler under full load. One is turbine driven, the other motor driven. All auxiliary turbine and motor drives and controls were furnished by Westinghouse Electric & Mfg. Co.

A Copes feedwater regulator is installed. This is of the "Flowmatic" type which operates from the steam flow and water level. Steam flow is measured by taking the drop across the superheater and water level by a Copes thermostat. The feed pump turbine is fitted with a Copes differential pressure governor and the feed pump motor with a differential pressure type valve.

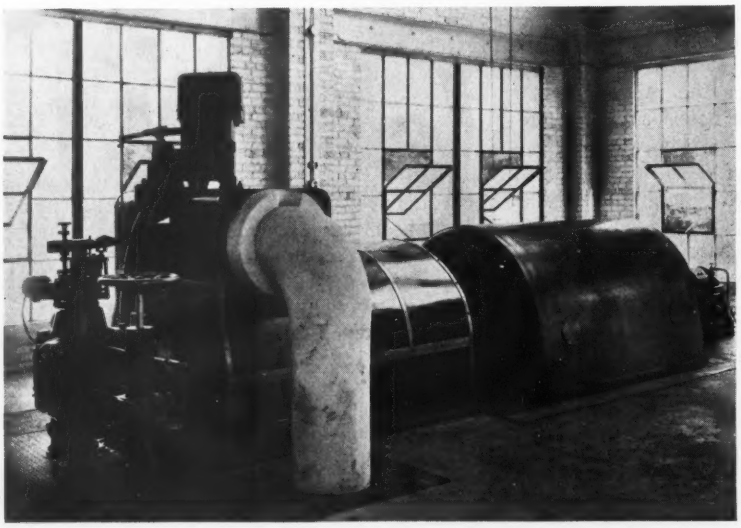


Fig. 7. The 2500 kw. non-condensing turbine unit

All steam passing through this turbine is used for process work in the mill. Current is generated at 480 v. 3 phase and is distributed through the mill at this voltage

Part II*. Coal Handling System, Combustion Equipment and Steam Generating Plant. The annual coal consumption of the completed Delray plant will approximate 600,000 tons per year, and of this amount Company policy requires that from 50,000 to 150,000 tons must be on hand at all times. A brief statement of the methods and equipment involved in handling, storing, preparing and sampling this large amount of fuel is here presented as a preface to the principal feature of this installment, the story of the design of fuel burning equipment and steam-generating plant.

High-Pressure Extension of Detroit Edison's DELRAY PLANT

By
MAX W. BENJAMIN
Engineering Division,
The Detroit Edison Co.

AT DELRAY facilities are available for receiving coal by rail and by self-unloading boats, both of which services are used in the normal course of events. An attractive differential on freight charges makes it desirable, however, to take as much waterborne coal as storage facilities and navigation conditions permit, even though considerable extra handling is required thereby.

Coal brought to the plant by boat is delivered onto the receiving wharf from the conveyor boom of self-unloading barges and pulled by drag line over a ramp from which it drops into coal cars that are then moved either to stock piles or into the coal unloading house. Coal to be stocked is unloaded and piled on the ground by means of a locomotive crane equipped with a conventional grab bucket while cars moving directly to the unloading house are emptied into track hoppers by means of a rotary car dumper. Coal received by rail is either dumped into the track hoppers upon arrival, or unloaded into stock piles in the same manner as with coal from the river wharf.

Breakers and Conveyors Installed in Duplicate

Beginning at the coal unloading house the preparation and handling system at Delray is direct and simple. Pan conveyors receive coal from the track hoppers by gravity and discharge into either of two 525 ton per hour rotary breakers which reduce the lumps to a size passing a 1½ in. screen. The crushed coal feeds by gravity onto feeder belts which load either of two 42 in. belts carried on an inclined bridge to the top of the boiler house. A portion of the belt bridge may be seen in the frontispiece view of the plant published in the March, 1939, issue of Power Plant Engineering.

Since the boilers are single-ended and arranged about a central firing aisle there is but a single row of bunkers in the plant. These bunkers, which in the completed plant will have a total capacity of 6000 tons, are filled from either of two horizontal 42 in. belts running lengthwise of the boiler room. From the bunkers the coal moves by gravity through spreaders to the stoker hoppers.

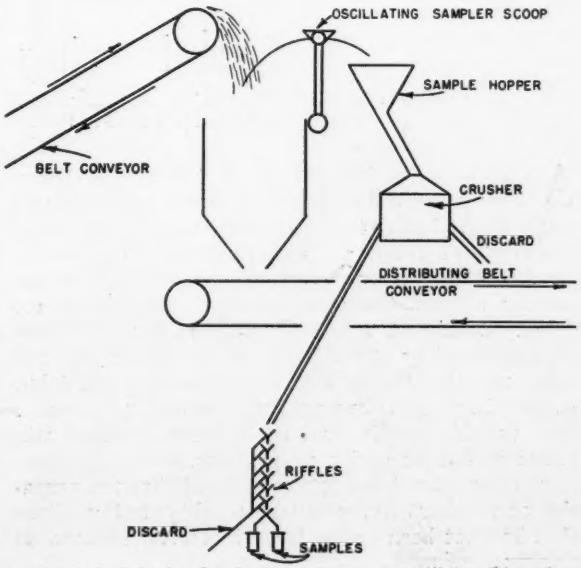


Fig. 15. Schematic arrangement of automatic coal sampler used at Delray

*Part I of this series of five articles was published in the March 1939 issue of Power Plant Engineering. The next installment will be printed in the July issue.

Automatic Coal Sampler

An automatic device is used to collect coal samples, the analyses of which are the basis of the calculated plant efficiency. The automatic sampler consists essentially of an intermittent sampling scoop, a small crusher, and a series riffle, as shown in Fig. 15. The sampling scoop, which is as wide as the belt, is located so as to dip into the coal stream just under the conveyor head pulley and passes through the stream in the length of time required to fill the scoop. The scoop then dumps into the sample hopper feeding the crusher, and returns to the coal stream for another load. Each scoopful weighs about 14 lb and the mechanism is timed for about one cycle per minute.

The crusher grinds the coal to pass a ¼ in. screen, discharges about five per cent of the sample to the series riffle and discards the remaining 95 per cent to the bunkers via the distributing belt. The crusher motor is interlocked electrically with the conveyor motors.

Each riffle divides the sample into two equal parts, discarding one-half and passing the other half on to the next riffle. Since there are six riffles in this series, the final sample consists of about 1/64 of the amount entering the first riffle, which, as noted above, is five per cent of the total sample taken from the coal stream leaving the bridge belt. Thus about 0.08 per cent of the total sample passes to a last riffle which merely divides it and deposits the two portions in duplicate aluminum containers provided with dust-tight covers. These containers are of adequate size to hold one day's sample. When the cans are removed at the end of the day the sample is sealed against absorption or loss of moisture by means of an inserted cover with expanding rubber gasket. One container is sent to the laboratory for analysis, while the other is held in reserve until the laboratory report is received.

Delray Plant

Fuel Burning Equipment

AT THE time of designing the first section of Delray Power House 3 a decision in favor of stokers was made on the basis of an exhaustive study of the relative merits of stokers and powdered coal. In this study the fly-ash disposal question was considered to weigh heavily against the advantages of pulverized coal firing. Continued research by The Detroit Edison Company and by others has led to the development of many uses for the fly ash from powdered coal,[1] but as yet the markets are not large enough to consume the available supply, and the disposal problem still exists as one of major proportions.

On the other hand it was realized that the operation of a stoker 57 tuyeres long would entail problems that had not been encountered in shorter stokers. It was judged, however, that operating economies and convenience together with a simple arrangement of bunkers and coal-handling system would offset the operating troubles that might arise with the long stoker. With this in mind the steel structure of the boiler plant was laid out so that any of the units could be changed over to pulverized coal firing if found desirable.

It is true there have been operating difficulties with the long stokers, and considerable thought and development work have gone into their design since the first ones were built. Among the important refinements are the schemes for automatically proportioning the air supply to obtain uniform distribution of air to the tuyeres and a controlled supply of air to the fuel bed. These improvements in design and construction along with the ever present difficulties attending the pulverized coal fly-ash problem encouraged the continued use of long stokers in the Delray extension.

Stokers

All the refinements in design and construction that have been found desirable during 35 years of operating experience with such equipment are embodied in the new stokers at Delray. Some changes have been made to improve operation; others have been adopted to reduce maintenance. Stokers in the Delray extention, like those in the first section of the plant, are single ended, 15 retorts wide and 57 standard tuyeres long. The tuyeres actually used, however, are thinner than standard, and 82 of them are required for each tuyere stack. Reference to Fig. 16 showing a sectional side elevation of the stoker will clarify some of the details described in the following paragraphs.

After being introduced into the retort by the ram, coal is moved down the length of the retort and into the ash pit by the action of four pushers and a reciprocating extension grate. Stokers installed in the first section of the plant were equipped originally with six square-nosed adjustable-stroke pushers per retort in addition to the reciprocating extension grate. It was soon learned that so much agitation of the fuel bed produced excessive smoke, and it was impossible to properly pack the coal in the retorts and control

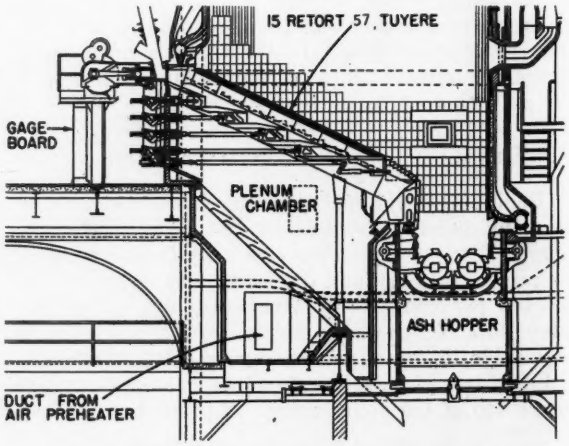


Fig. 16. Sectional side elevation of the new Delray stoker

[1]See "Possibilities for Utilization of Pulverized-Coal Ash" by A. W. Thorson and J. S. Nelles, Mechanical Engineering, November, 1938, p. 845.

its flow as it moved from the front to the rear of the stoker. This resulted in an uneven fuel bed and improper combustion which often caused the burning of iron.

The first step toward improving conditions was to install lower-angle ram-box caps and to substitute longer, bevel-nosed bottom pushers for the square-nosed ones. The low ram-box caps result in better packing of the coal at the stoker front. A bevel-nose shape for the bottom pusher has been found particularly suited for removing clinkers from tuyere plates and coal plate extension noses. After these changes were made it became evident that the use of fewer pushers would deepen the retort to produce still better coal packing and enable the operator to maintain a more uniform fuel bed with less agitation. As an experiment one stoker then was converted to a five pusher arrangement and another to a four. At the same time the sectional side cover plates of the retorts were replaced with one-piece steel side plates to permit any necessary further changes to the pusher arrangement without again rebuilding the retorts, and to reduce the amount of siftings through the retort side plates.

Operation with five pushers was somewhat better than the original design, while the stoker with four pushers showed a decided improvement over either the five or six pusher arrangement. Less smoke was produced, higher CO_2 values were attained, there was less clinkering and burning of iron, and a wider range of fuels could be burned efficiently. This experience dictated the conversion of the three remaining stokers in the first section of the plant to the four pusher arrangement, the use of four pushers in stokers throughout the plant extension, and the use of a two-pusher arrangement on the double-ended stokers at Conners Creek. It was thought inadvisable to experiment with less than four pushers since that would involve moving too large a portion of the fuel bed with each pusher.

Among the operating experiences with stokers in the first section of the plant were certain difficulties that suggested further refinements for units in the plant extension. Wet coal which is supplied during the winter months, sometimes holds up in the stoker hoppers, arches over the rams at the ram-box throats, or forms cones of coal on the ram faces which result in the loss of coal-feed. Failure of coal-feed to retorts of such depth and length, together with earlier ignition due to preheated air, has resulted in serious burnouts.

In an effort to prevent the formation of cones of coal on the ram faces, a removable cap was developed to be attached to the end of the ram. This cap has no recesses into which coal can pack and begin the formation of cones of coal on the face of the ram. It is also beveled so that the bottom of the cap extends into the ram-box 1 in. farther than the top edge. At date of writing the face of this removable cap shows no signs of cones of coal building up on it. It is polished, indicating that the upward movement of coal across the face prevents the adhesion of coal. It is possible the only difference in adjustment of the stoker with the beveled ram instead of the straight faced ram will be a slight increase of strokes of the first and second pushers.

The improved ram is of no help, of course, in cases where the failure of coal feed is caused by holding up in the stoker hoppers or arching over the ram-box throat. To combat this difficulty work is going forward on the design of an agitator which will operate to prevent the packing of coal. As now proposed this device consists of a series of shoes carried on a movable rod inside the coal hopper and driven independently or by the stoker mechanism in such manner as to move a few inches back and forth crosswise of the stoker. There is one shoe for each retort, traveling in the space above and between adjacent ram-boxes.

Another refinement in design concerns the stoker support, which in the original units consisted of two 20-in. steel plates per retort. The plates were not sufficiently rigid, however, and a certain amount of sagging which resulted from the weight of the fuel bed and from thermal expansion of the retorts caused binding of the moving parts and disturbances in the air control arrangement. Because of these difficulties the 20 in. support plates were replaced with 24 in. plates which also were reinforced with the one piece retort side plates secured to them with close-fitting bolts. However, some sagging still occurs, and in the new stokers another change has been made. Rather than reinforce the support plates still further, the new design incorporates a cross-beam carried on six pin-ended struts and hinged to the support plates of each retort at a point immediately below the lowest pusher, about 2/3 the length of the stoker from the coal ram. The extreme lower ends of the support plates are carried on rollers, as before, to allow for longitudinal expansion of the stoker. Figure 16 shows

Fig. 17. View inside the stoker plenum chamber showing "shedding plates" and strut supports under retorts

the supporting arrangement in side elevation, while Fig. 17 is a photograph of these members.

It is expected that two benefits will be obtained by using the strut supports. First, the struts will expand vertically when warmed by the preheated air in the plenum chamber, thus tending to lift the entire retort, take the load off the expansion rollers and throw the support to a point underneath the lower pusher. This not only shortens the unsupported span of the retort but leaves the lowest tuyeres and extension grates overhanging the strut with a counterbalancing influence which further reduces the amount of deflection in the support plates. A second effect of the strut is to permit free longitudinal expansion of the retort due to the reduction of load on the rollers at the low end, thereby eliminating distortion that might be produced by end thrust caused by rolling resistance.

The use of refractory blocks on the extension grates and tuyere and coal-plate extension noses on the old stokers has been found effective in reducing the maintenance of these parts, and has been continued on the new stokers. In addition the cast-iron grate-guards of the new stokers have been replaced with similar refractories. With the coals burned at Delray molten ash does not fuse on these refractories.

Practice With Respect to Combustion Air Control

Operating experience with double-ended stokers of 21 and 29 tuyere length had indicated that some form of regulation of the combustion air supplied to the tuyeres and extension grates would help in maintaining good combustion and sustained high fuel-burning rates.

Experimental work at the Marysville plant on combustion-air control pointed the way for future development, and a system of automatic control by zones was developed for the 57-tuyere stokers in the first section of Delray PH 3. While the results were not all that could be desired, this air-control arrangement has been of considerable value in maintaining proper combustion.

At the Beacon Street Heating Plant experiments with air control were proceeding along somewhat different lines. Both at Marysville and at Beacon Street the stokers were divided into small areas, checkerboard fashion, but in this case arrangements were made to supply air to each section through a duct in which there was an adjustable damper that could be regulated manually through a wire similar to the choke wire of an automobile carburetor. Each duct contained a venturi section, with a manometer connected into the throat to register an indication of the amount of air flowing through it. The manometers and the damper controls were all arranged accessibly, enabling the operator to control the amount of air supplied to each section of the stoker.

This type of control was refined and developed to a point where the damper operation was made automatic to maintain any desired amount of air flow in any zone and could be regulated by adjustment of the loading on one side of the diaphragm of an automatic regulator. In this form the air control is installed at Connors Creek as described in the booklet "Modernizing the Conners Creek Power Plant."

Schematically the automatic metered air control at Conners Creek is relatively simple, but the investment required for its construction and installation is a rather significant item of the boiler-plant cost. Operation has been sufficiently gratifying to warrant the replacement of one of the older type air-control systems at Delray with the new metered type, adapted, of course, to the 57-tuyere stoker. It was intended that any necessary modifications would be worked out on this first installation, after which the remaining old boilers, as well as the new boilers in the plant extension, would be fitted with the new type of air control. The actual results obtained with this type of automatic metered air control adapted to the long Delray stokers, however, were not as satisfactory as the application to the shorter stokers at Conners Creek.

By this time a new type of tuyere had been developed which gave considerable promise of eliminating some operating difficulties without the use of an automatic air control. One of the older stokers at Delray was equipped with these new tuyeres to gain experience and to learn first hand what benefit could be expected from their use. The new tuyeres were satisfactory on test producing combustion results considered by the operators to be practically as good as those obtained with the new type automatic air control. Accordingly it was decided to adopt this new tuyere design for the plant extension and omit for the time being the automatic air control until further developments reduce its initial cost of installation. The plenum chambers are so constructed that the automatic air control can be added later if desired. While the tuyeres receive combustion air by natural distribution, manually operated dampers are installed for adjusting the flow of air to the moving and stationary extension grates and for adjusting the flow of secondary air supplied over the fire at the stoker front.

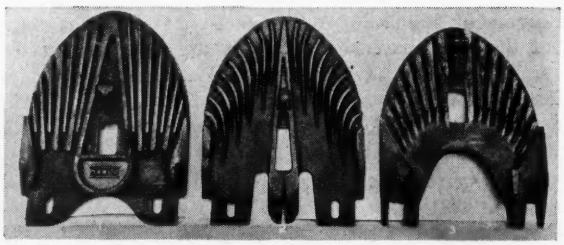


Fig. 18. Three different tuyere designs used at Delray. Note the restricted throats in the Noblo design used with the new stokers

The Noblo Tuyere

The new tuyere mentioned above, which has been named the "Noblo", is shown as tuyere No. 1 in Fig. 18. In comparison with tuyeres 2 and 3 of the same figure the main differences lie in its multiple venturi-shaped air passages and the fact that the restricted entrances of these passages produce a certain amount of orifice effect tending toward good air distribution as between different tuyeres. The No. 2

tuyere is the type used at Conners Creek and on the stoker at Delray equipped with the new automatic metered air control. Tuyere No. 3 is the type in use on the Delray stokers having the older form of air control equipment.

Because the configuration of the Noblo tuyere may lead to a misunderstanding of its real characteristics some discussion of its operating principle may be in order. A truly self-limiting tuyere would have a flow characteristic like that of an orifice passing an elastic fluid, definitely limiting the amount of air that could pass through a thin spot in a fuel bed, thus slowing down the progress of the vicious circle in which the thin spot gets thinner while the normal portions of the bed receive an insufficient amount of air. Actually, as is well known, the capacity limit of such a device is not attained until the ratio of the final to the initial pressures becomes about 53 per cent. In stoker operation the furnace pressure ordinarily is about atmospheric while the plenum chamber pressure amounts to only a few inches water gage pressure. It is entirely impracticable for the ratio of pressures across a stoker tuyere even to approach the 53 per cent value required to reach the constant capacity point. While the air passages of the tuyere appear to be expanding nozzles their chief function is to distribute air across the face of the tuyere. Their shape has no other significance of importance.

The whole aim of the Noblo design is merely to approach the orifice characteristic, an effect which is emphasized by the carrying of lighter fires with Noblo tuyeres than is customary with normal tuyeres, thereby producing a steeper pressure-flow relationship tending to reduce the flow through a thin spot in the fuel bed as compared with the flow that would obtain with a normal tuyere. This is illustrated in Fig. 19, plotted from data furnished for the Delray installation.

Some operating advantages for the new tuyere over the more expensive air control as found on test are summarized below:

1. Lower plenum chamber pressure
2. Equal steam generating economy
3. Higher maximum output over prolonged periods
4. Stable operation at maximum forcing
5. Less fuel blown from the grates at comparable ratings.

The Noblo tuyere appears responsible for improved stoker operation, but the results are not as good as those obtained on the shorter stokers at Conners Creek with their automatic metered air control, either in manageability of the fire or in maintenance cost. The final solution of this problem of air control for the long single-ended stoker is not yet apparent.

The clinker grinder for each stoker consists of two rolls, each having a shell diameter of 26 in. and a diameter of 34 in. over the teeth, driven by an adjustable speed motor through a selective engagement of ratchet and pawl to obtain a speed range of 20 to 1 with actual roll speeds of from 0.164 to 3.28 revolutions per hour. Clinkers are crushed against adjustable aprons to a size suitable for disposal, and drop into an ash hopper from which they are dumped into railroad cars to be hauled away. To facilitate grinding a small amount of general service water is introduced continuously into the ash pit through openings at the top of the lower grate. Refinements of design to promote uniformity of grinding throughout the length of the grinder consist in the use of narrower brackets for intermediate support of the rolls, and grinder teeth which are offset so that grinding will be more effective at the ends of the shells adjacent to the intermediate supports. A portion of the ash pit and clinker grinder is shown in Fig. 20.

The pronounced downward expansion of the front water wall of the boiler was accommodated by building the stokers with longer front wall air-back bars and higher ram-box extension cap covers.

The internal arrangement of the plenum chamber is peculiar to the stokers at Delray inasmuch as the

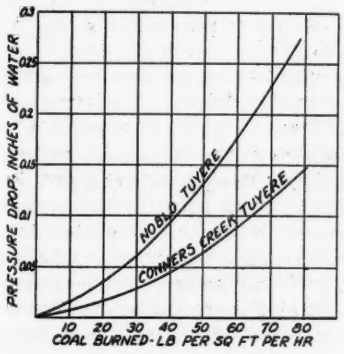


Fig. 19. Comparison of pressure losses through Noblo tuyere and the tuyere used with automatic metered air control

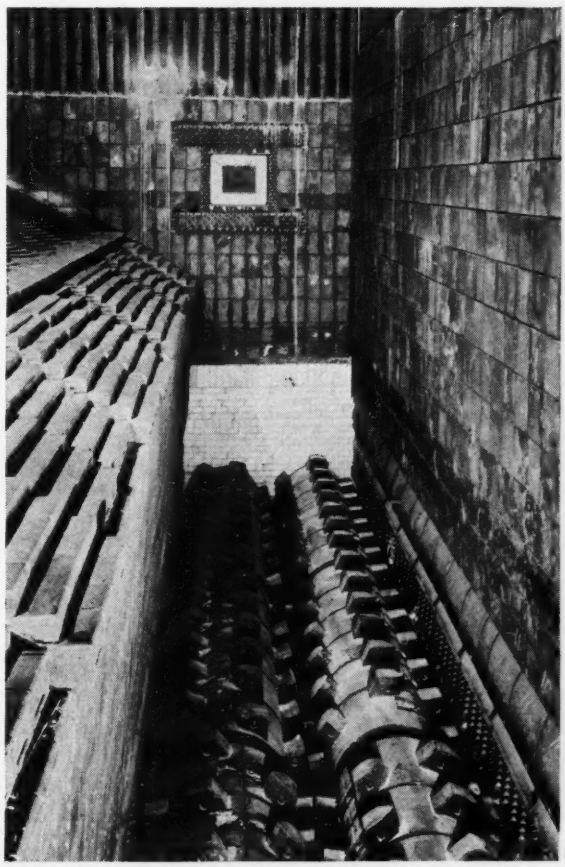


Fig. 20. Extension grates and clinker grinder in one of the new stokers

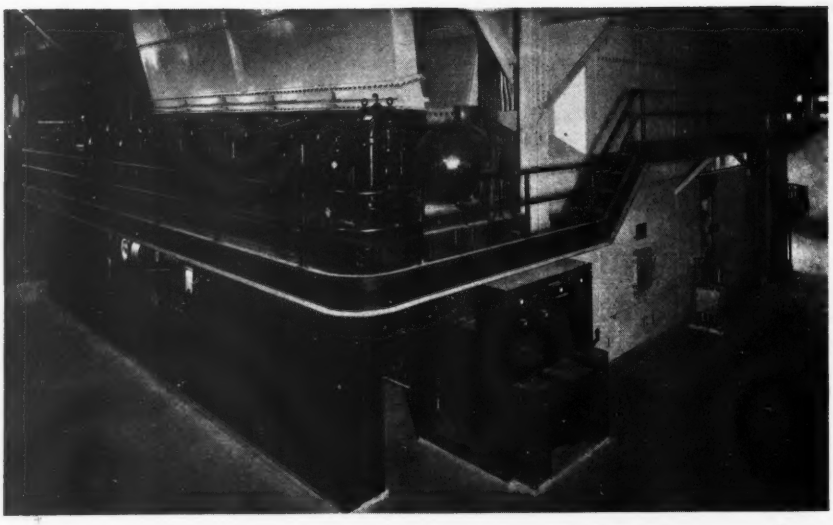


Fig. 21. Exterior view of the steam generating unit showing stoker driving mechanism and boiler gage board

siftings disposal system necessitates the installation of "shedding plates" between the stoker and the bottom of the plenum chamber. The shedding plates are arranged shingle-fashion as shown in Figs. 16 and 17 to direct the stoker siftings toward a hopper where they are collected and spouted into cars to be hauled away with other stoker refuse. Generous passages are provided between the overlapping portions of the shedding plates for air to reach the stoker.

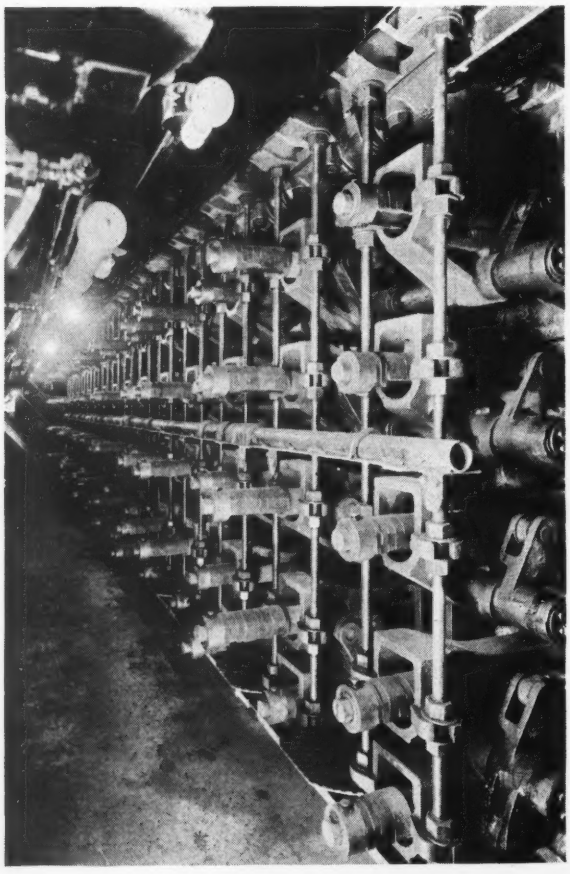


Fig. 22. Pusher mechanism showing stroke adjustment. This mechanism is located behind the boiler gage board where it is readily accessible to the operator

Stoker Driving Mechanism

Externally the new stokers are similar to the earlier ones at Delray. Each is driven by a two-voltage adjustable speed d.c. motor having an overall speed range of 8 to 1, direct connected to a two-speed reducing gear having ratios of 4 to 1 and 10 to 1. The slow speed shaft of the reducing gear is, in turn, direct connected to the stoker speed shaft which drives the stoker in five sections of three retorts each. Between the speed shaft and each stoker section is a two-speed gear box which provides further reduction ratios of 132 to 1 and 198 to 1. With this driving mechanism which is assembled on a platform above the boiler gage board as shown in Fig. 21, it is possible to obtain stoker speeds over a range of 30 to 1 as compared with a range of 12 to 1 on the older units. The above described driving mechanism permits a speed adjustment of from 0.126 to 3.78 strokes per minute of the coal feeding ram. Gear boxes and other parts of the driving mechanism are of high class construction, built to standards of accuracy that compare favorably with the best of modern machinery.

The extension grates and four pushers for each retort are operated from the coal ram mechanism through links and bell cranks as shown in Fig. 22. As has been noted, the stoker is driven in sections of three retorts; each section having its own two-speed gear box. In addition to this degree of independent speed control of the different sections, it is possible to adjust the length of strokes of the individual pushers and extension grates. The strokes are changed by varying the number of spacers between the pusher mechanism and a collar at the end of the pusher rod, as on the older stokers at Delray. Spacers are C-shaped pieces of steel of various thicknesses, visible in Fig. 22, which are merely dropped onto the pusher rod to lengthen the stroke or lifted off the rod to shorten

the stroke. Extra spacers may be seen on the horizontal pipe just below the second row of pushers.

The design of the pusher guide casting has been refined since the older stokers were built. Pusher guides shown in Fig. 22 have rectangular shaped tops with ample clearance above the spacers, while those in the older stokers were made with a circular opening at the end that provided a limited amount of clearance. On some occasions the spacers became wedged between the end of the guide casting and the pusher rod, causing breakage of the guide casting. In view of this experience the new style of casting, which was designed first for the Brooklyn Edison Company, has been adopted for the Delray extension.

TABLE IV—TYPICAL ANALYSIS OF COALS USED AT DELRAY

	Normal Coal	Lower Grade Coal
Proximate Analysis, as received		
Volatile %	34.00	34.88
Fixed Carbon %	53.10	45.87
Ash %	8.65	12.25
Moisture %	4.25	7.00
Heating value as fired, B.t.u. per lb.	13,200	12,000
Ultimate Analysis, Dry Coal		
Carbon	75.36	70.03
Hydrogen	5.07	4.80
Nitrogen	1.24	1.23
Oxygen	8.20	7.14
Sulphur	1.09	3.64
Ash	9.04	13.16
Softening temperature of Ash, F.	2,500	2,100

Figure 23 indicates design performance of the stoker when burning fuel of normal quality. It is stipulated that the stoker shall be capable of burning enough coal of a lower grade to carry the full load rating of the boiler. Analyses of the two grades of coal are given in Table IV.

BLAST FURNACE GAS BURNERS

Arrangements were made in 1936 and 1937 for burning as an auxiliary fuel the surplus gas produced in blast furnaces of the Hanna Furnace Division of the Great Lakes Steel Corporation about ¾ of a mile from the Delray plant. This gas, a typical analysis of which is given in Table V, has a net heating value of from 90 to 95 B.t.u. per standard cubic foot.

Arrangements have been made to burn up to 50,000 cfm of the gas as a maximum, with an annual consumption equivalent to 60,000 tons of coal. When the gas contract was negotiated only the low-pressure section of the plant existed and gas burners were installed on three of the five boilers. At the time of this writing two of the new boilers are equipped with identical burners and another unit will be so equipped when it is installed.

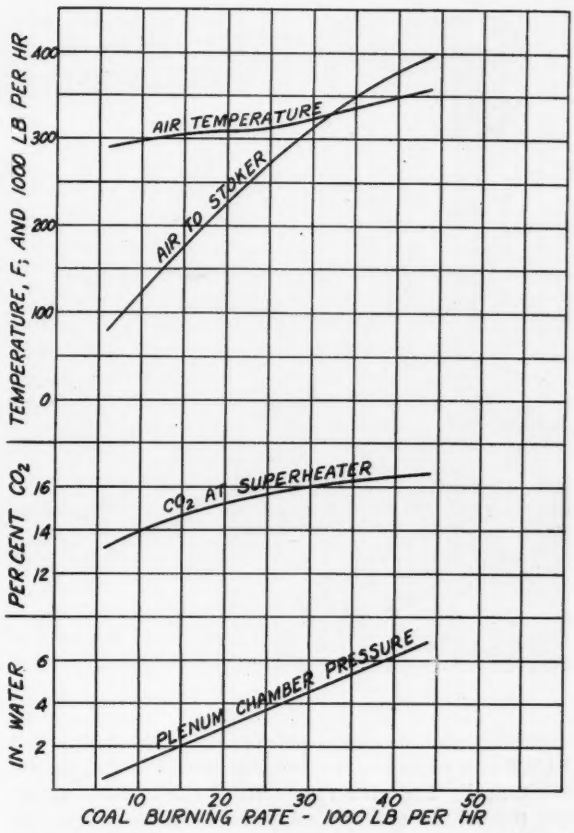


Fig. 23. Performance conditions assumed for stoker design

Gas is conducted from the blast furnaces to Delray through a 48-in. diameter line some 5000 ft long of which over 2400 ft are underground. A length of 303 ft crosses the Rouge River on a specially constructed bridge shown in Fig. 24 which provides clearance of 150 ft above the river level. The pipe line is built up from rolled steel plate, welded lengthwise and circumferentially into sections about 80 ft long, joined to each other by Dresser couplings. A 48-in. diameter header runs the entire length of the boiler house above the operating floor to feed 36-in. diameter branches for each of the boilers on the west side of the boiler room.

TABLE V—BLAST FURNACE GAS ANALYSIS

Constituent	Percentage by Volume
Carbon Monoxide	24.0
Carbon Dioxide	11.0
Hydrogen	3.0
Oxygen	0.3
Methane	0.2
Nitrogen	61.5
Total	100.0

In the back wall of each furnace thus equipped, are installed four grid-type gas burners, designed and built by The Detroit Edison Company. Each burner is designed for an operating range of 4 to 1 with a

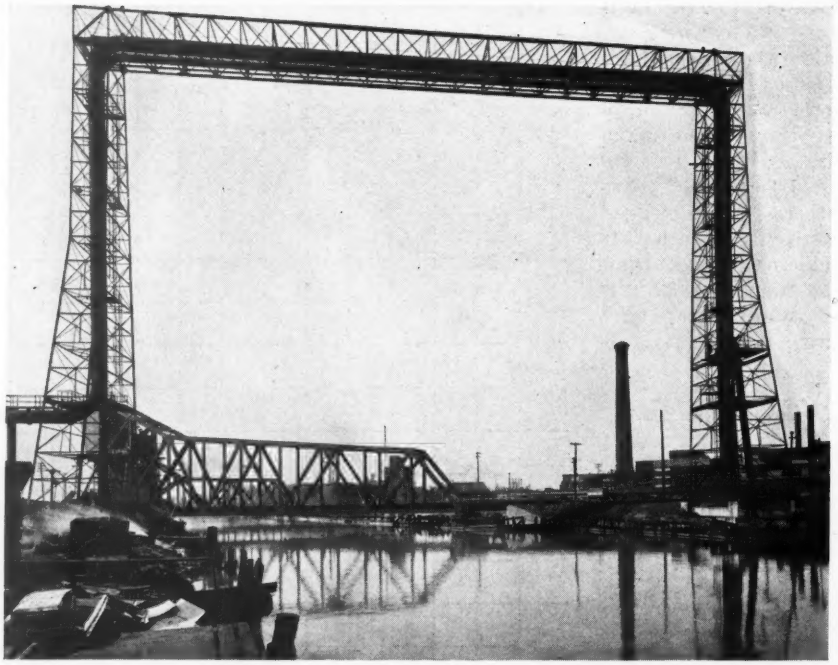


Fig. 24. Bridge carrying the 48-in. blast furnace gas line over the River Rouge

normal maximum capacity of 7500 cfm of gas and 10,500 cfm of air. The burners are arranged to fire horizontally from the rear wall of the furnace across the top of the stoker fuel bed as shown in Fig. 16. A photograph inside the furnace showing the burners in a new boiler is reproduced in Fig. 25.

In the case of the three older boilers, a major reconstruction of the rear walls would have been necessary to accommodate burners of standard design. This was avoided by using burners of the inter-tube diffusion type shown in some detail in Fig. 26. Refractory material between the furnace wall tubes and the burner was found necessary to protect the burners from radiant heat when no gas was being burned. The 36-in. diameter branch supplying gas to the burners of each boiler can be shut off from the header by means of a solenoid-operated quick-closing butterfly valve, but whenever it is necessary for men to work inside the furnace a U-leg in the gas duct is filled with water to provide a positive seal. Gas to each burner passes through a grid-type valve in the burner branch line. By means of these valves any one or more of the burners may be turned off, depending upon the supply of gas. Air is supplied to the burners from the preheated air duct, the amount of air being regulated automatically to maintain the desired air to gas ratio.

Because coal and blast-furnace gas have such widely different combustion characteristics it is necessary to follow a special operating procedure when the two fuels are burned simultaneously in the same furnace. The scheme adopted requires metering the gas to each boiler, and works out as follows. Available gas, together with its combustion air, is supplied through the burners, with automatic regulation of the air-gas ratio. The remainder of the load is carried by coal which, with its combustion air, is regulated manually. Having previously determined the optimum air-gas and air-coal ratios by special tests, the desired percentages of CO_2 in the mixed flue gas are known for different boiler steaming rates and different gas-coal ratios. The operator makes adjustments to obtain maximum CO_2 without CO and H_2, using as a guide the CO_2 data computed from tests, together with the observed boiler steaming rate and gas volume.

Forced and Induced-Draft Fans

Forced and induced-draft fans in the plant extension are the same size as those of the first section. Except for minor modifications, the rotors of the respective fans are interchangeable. On the forced-draft fans the scrolls also are duplicates of those in the first section, but the increased height of the new boilers required a change in the inlet connections of the induced-draft fans which also have been built with slotted scrolls for separating the cinders and

Table VI—Rating Data on Forced and Induced Draft Fans

	Plant Extension	First Section
Forced Draft		
Size, two per boiler	9½	9½
Combined Capacity, cfm at 60 F	106,600	130,000
Net Static Pressure, in. H_2O	15.7	12.5
Speed, rpm	1,000	925
Induced Draft		
Size	13	13
Capacity, cfm	189,000	233,000
Gas Temp, F	350	350
Net static pressure, in. H_2O	15.5	13.9
Speed rpm	975	930

the heavier dust particles from the gas before it goes to the stack. This is the well-known "Cinder Fan."

Although the corresponding fans are dimensionally of the same size in the two sections of the plant, their ratings are quite different, as shown in Table VI.

It will be noted that both the forced and the induced-draft fans are required to operate at lower capacities but against higher heads in the plant extension than in the first section.

Reductions in fan capacity for the same fuel burning rate were permitted by

(1) Designing for higher CO_2, anticipated as the result of better distribution of air to the fuel bed by means of automatic metered air control or its equivalent.
(2) More nearly gas-tight construction of air heater, and of air heater and economizer casings.
(3) Gas tight preheated air ducts, assured by welded construction.
(4) Welded steel furnace casings which minimize infiltration.

Two arbitrary rules were set up for determining the maximum fan capacity. The first of these is that the fans must be of sufficient rating to provide draft for 20 per cent more than the rated coal burning capacity of the stokers when operating with normal coal. The second is that the fan ratings must be adequate to develop the rated output of steam from the boilers when the poorer grade of coal is burned. In the case of the new units the latter requirement is the more severe, and the fans designed on that basis are large enough to operate the stokers at nearly 29 per cent overload with good coal.

The increase in static pressure against which the new fans operate results from the increased friction loss through the air heater and economizer in consequence of the greater amount of heating surface in these units. These heat retrievers had to be made larger, of course, because of the higher saturation temperature at which the boiler operates, and the higher temperature of the feedwater as it enters the economizer. The draft loss through the superheater also is greater than in the older units because of the greater amount of surface needed and because of the dampering loss that accompanies the by-pass compensating feature. The latter will be described in more detail later.

Draft is controlled by manual regulation of the fan speed except at very light ratings when it becomes necessary to throttle with dampers. Both fans are driven by adjustable speed dc motors having field control down to ½ of full speed. The speed of each fan is regulated through a 120 point rheostat, motor operated from controls located on the boiler gage board.

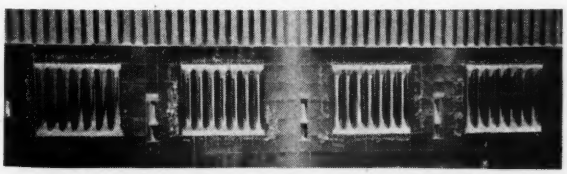


Fig. 25. Diffusion-type gas burners in the rear furnace wall

Delray Plant

Steam Generating Equipment

THE FACT that the building columns in the plant extension are arranged with identical centering as those in the first section coupled with the decision to fire with stokers quite definitely fixes the maximum hourly heat liberation in each new furnace at approximately the same value as for the first section. Steam conditions and feedwater temperature in the extension also require very nearly the same boiler room heat absorption per pound of steam as obtains in the older boiler plant. Normal maximum steaming rates of the old and new boilers are, therefore, very nearly the same, being 340,000 and 344,000 lb per hr respectively. There is a considerable gain in kilowatt rating per boiler, however, because of the reduced plant steam rate at the higher initial pressure and temperature. Under conditions assumed in design the normal maximum evaporation of the old boilers provides steam for about 29,000 kw of plant output per boiler. The corresponding figure for the new boilers is 38,000 kw.

Boiler

In design the new boilers present several radical departures from practices found in earlier Detroit

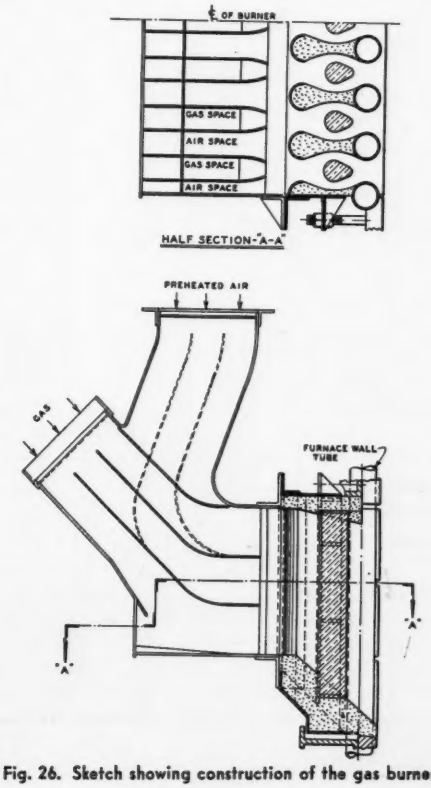


Fig. 26. Sketch showing construction of the gas burners

Edison plants. A comparison of Figs. 27 and 28 shows the pronounced difference between the old and new boilers at Delray, which is emphasized by the data given in Table VII.

Experience at Conners Creek with the high CO_2 values attainable with automatic metered air control showed that the furnace should be completely water cooled to prevent excessive combustion temperatures and attendant slagging. The new units at Delray are designed for relatively low heat releases in large furnaces that are as nearly 100 per cent water cooled as possible. To accomplish such extensive furnace cooling, tubes 3¼ and 2$\frac{11}{16}$ in. OD are used alternately on 6 in. centers across the entire width of the front and side walls as shown in Fig. 29. The rear wall is built up of 3¼ in. OD partially studded tubes on 6 in. centers, with plastic chrome-ore refractory filling the spaces between tubes. At the top of the furnace the first two rows of tubes in the convection boiler are arranged to act as a slag screen for the remainder of the boiler and superheater. Figures 30a, 30b, and 30c show portions of the front, side, and rear walls, respectively, of the completed furnace. Figure 31 is a view looking vertically upward from the ash pit to the top of the furnace, a height of approximately 60 ft.

Cast-iron blocks which protect the side and rear furnace walls at the stoker line and ash pit obviate extending the 2$\frac{11}{16}$ in. diameter water wall tubes all the way to the lower headers. These smaller tubes therefore are terminated in headers some 12 or 13 ft above the lower ends of the stoker retorts. Spaces between the 3¼ in. tubes from the top of the iron blocks to the point where the 2$\frac{11}{16}$ in. tubes enter the furnace, are filled with plastic chrome-ore refractory. The 3¼ in. tubes are partially studded in this region as shown in Fig. 32. Just above the studded portion may be seen the lower ends of the 2$\frac{11}{16}$ in. tubes as they come into position between the larger tubes in the furnace wall.

TABLE VII—COMPARISON OF HEATING SURFACE DISTRIBUTION IN DELRAY BOILERS

	New Boilers			Old Boilers		
Surface	Sq Ft	Per Cent Surface	Per Cent Heat Absorbed	Sq Ft	Per Cent Surface	Per Cent Heat Absorbed
Water Walls	4948	7.0	61.5	3500	5.4	79.2
Convection Boiler	8188	11.5		23,900	36.7	
Superheater	9353	13.2	23.75	4900	7.5	15.8
Economizer	18,300	25.7	14.75	6032	9.2	5.0
Air Heater	30,200	42.6		26,920	41.2	
Total	70,989	100.0	100.0	65,252	100.0	100.0

All boiler and water wall tubes are of low-carbon steel, specified for a hardness not to exceed 70 on the Rockwell B scale while the actual hardness of the drum material averages 73. Water-wall headers are all 11¾ in. OD, of forged carbon steel. The upper headers are 1 in. thick and the lower ones are 1¼ in. thick.

The convection boiler is a relatively small three-drum Stirling unit consisting of only eight rows of 3½ in. OD tubes in two banks. Three rows of tube holes on 7½ in. centers in the 36-in. diameter steam drum accommodate four rows of tubes on 15 in. centers and one row on 7½ in. centers. Separation of the two front rows to make four rows on 15 in. centers is necessary to prevent bridging the space between tubes with slag when poor coal is used. Five rows of tubes in the rear bank are spaced on alternate centers of 6⅝ and 5⅜ in.

The boiler drums are constructed of rolled silicon-killed carbon-steel plate having a tensile strength of 70,000 lb per sq in. electrically welded in accordance with the rules for such construction set forth in the ASME Boiler Code. The feed drum is of uniform thickness, but a saving was effected in the steam and mud drums by using thinner material for the shell plates than was necessary for the tube sheets themselves. Principal dimensions of the boiler drums are as follows:

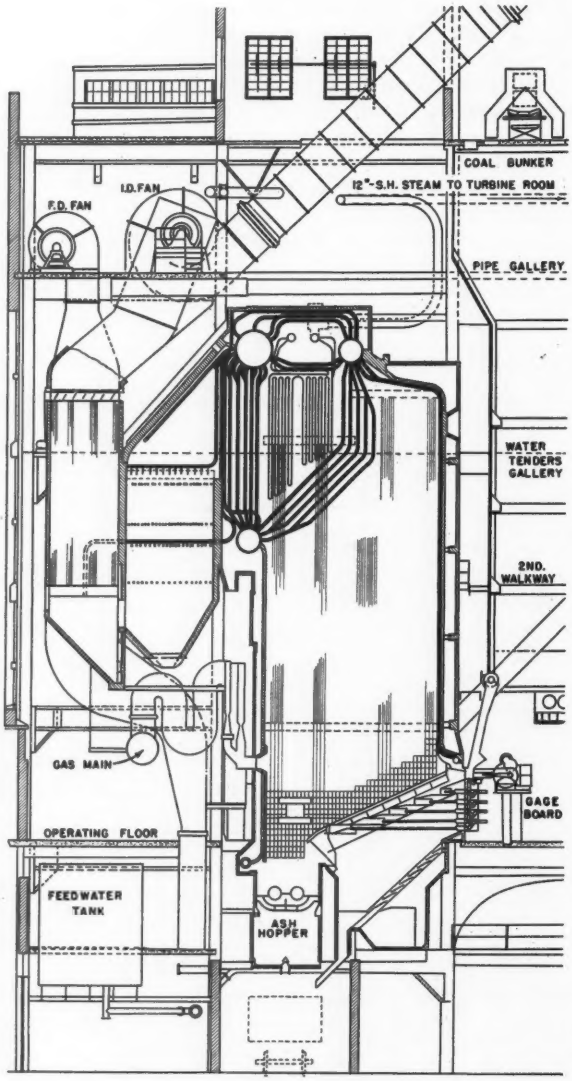


Fig. 27. Sectional elevation of steam-generating units in the Delray extension

PRINCIPAL DIMENSIONS OF BOILER DRUMS

Drum	Nominal I.D.	Length	Thickness Tube Sheet	Shell Plate
Feed	53⅞ in.	37 ft 9½ in.	$2\frac{9}{16}$ in.	$2\frac{9}{16}$ in.
Steam	35⅝ in.	36 ft 7¼ in.	$2\frac{9}{16}$ in.	$1\frac{11}{16}$ in.
Mud	35⅝ in.	28 ft 11¼ in.	3⅛ in.	$1\frac{11}{16}$ in.

Before going on to the remaining parts of the steam generator it will be well to discuss the boiler circulation system shown in Fig. 33, since it differs from previous practice.

Feedwater enters the boiler through spray heads located immediately below the steam scrubber and above the water level in the 54 in. upper rear drum shown in Fig. 34. By this method of introduction the feedwater does not disturb the level in the drum and at the same time provides a sheet of water for the steam to pass through before entering the scrubber. The feedwater, together with water recirculated from the front drum, passes downward from the 54-in. drum through the rear bank of boiler tubes and into the mud drum. Water supply for the rear water wall is taken in turn from the mud drum which also furnishes part of the water needed by the side and front walls. The remainder of the supply to the side and front walls is taken from the ends of the 36-in. steam drum.

Hot water and steam generated in the rear wall are discharged behind a baffle in the mud drum to become the supply for the front bank of boiler tubes. The front wall and the front bank of boiler tubes discharge water and steam behind a baffle in the 36-in. steam drum. The front halves of the two side walls discharge from upper headers through tubes which enter the 36-in. steam drum behind the baffle, while the rear halves of the side walls discharge from separate upper headers through two tubes that enter the drum behind the baffle and eight tubes which enter the drum on the opposite side and communicate with the space behind the baffle through internal passages built of steel plate. The partially completed baffling in the front steam drum is shown in Fig. 35. All steam generated in the equipment is released behind the baffle in the steam drum, the mixture of steam and water delivered by the tube risers being discharged over the top of the baffle into the larger compartment of the drum where separation takes place. The water flows back to the feed drum through circulating tubes while the steam passes out of the top of the drum through steam tubes which discharge into the steam scrubber in the feed drum, and thence to the superheater.

The circulation system was designed for a ratio of 11 lb of water to 1 lb of steam. Tests under a variety of operating conditions have shown the design ratio to be exceeded in all parts of the circuit, the circulation varying from 12.3 to 55 lb of water per lb of steam in different sections of the steam generator.

SUPERHEATER

The advantages of constant superheat obtained by controlled gas flow had been demonstrated at Conners Creek and earlier at other stations, so that one fundamental condition to be met by the new boilers was

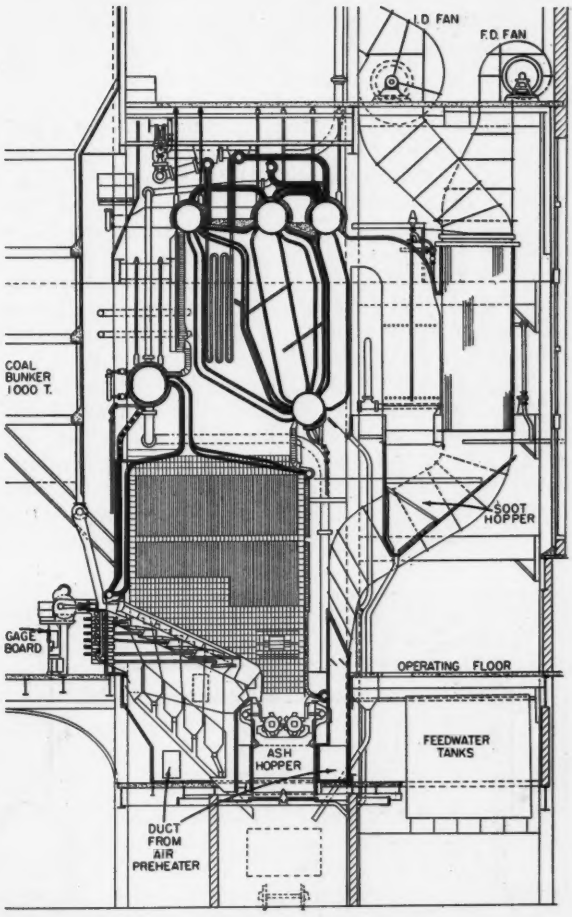


Fig. 28. Sectional elevation of steam-generating units in the first section of the plant

that of constant steam temperature over a wide range of output. However, the decision to use a three drum boiler, together with physical restrictions imposed by the building steel, limited the number of methods feasible for accomplishing the desired temperature control. Location of the by-pass dampers constituted the essential difference between various schemes. Any plan in which the dampers are located in the relatively cool zone at the economizer outlet suffers the disadvantage of partially by-passing the economizer; and conversely, any arrangement in which the gas streams are mixed ahead of the economizer requires the installation of control dampers in a hot zone near the boiler outlet. As between these alternatives it was believed that the dampers should be located at the economizer outlet, even at the expense of some sacrifice in economizer performance. This decision also permitted the simple baffling which could be used with the by-pass type of superheater.

Discussion of the relative merits of the divided-flow and by-pass types of compensating superheater failed to reveal any appreciable differences, either in the amount of surface needed, in performance, or in cost. With either type as large a portion of the gas flow as practicable would pass over the superheater

at minimum load, and if both were designed for the same steam temperature at this rating approximately the same amount of surface would be required for either type. The divided-flow type does not permit any more advantageous scheme for the recovery of heat beyond the boiler outlet than could be developed for the by-pass type, and the final steam temperature is controlled about as easily with one as with the other. Because the superheater does not extend across the full width of the furnace the tube spacing was made closer in the by-pass design, resulting in a small increase in draft loss. On the other hand, the divided-flow design would have required more complicated baffling. After taking all of these factors into consideration it was decided to use the by-pass type.

The superheater is of the counter-flow convection type consisting of 70 panels of nine pendant loops each arranged in two banks of 35 panels, one on either side of the boiler. Between the superheater banks is a blank space almost 7 ft wide which constitutes the gas by-pass that permits control of the final steam temperature. Partitions extend from the front loop of the superheater to the rear wall of the economizer casing to isolate the by-pass from the gas passes on either side. By-pass control dampers are located at the bottom of the wall between the economizer and air heater.

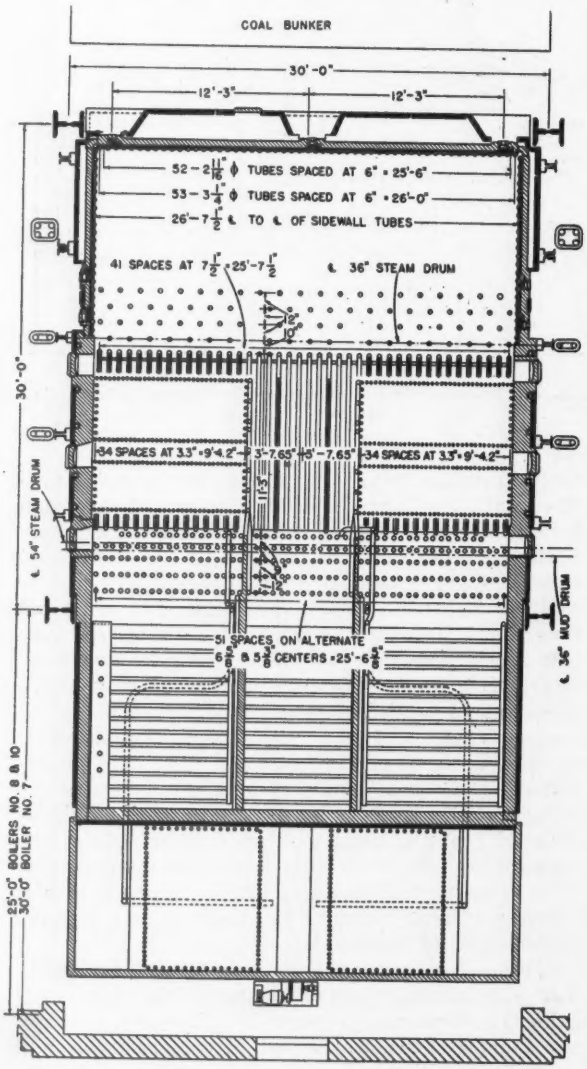

COAL BUNKER
30'-0"
12'-3"
12'-3"
52 - 2 11/16" ϕ TUBES SPACED AT 6" • 25'-6"
53 - 3 1/4" ϕ TUBES SPACED AT 6" • 26'-0"
26'-7 1/2" ℄ TO ℄ OF SIDEWALL TUBES
41 SPACES AT 7 1/2" • 25'-7 1/2"
℄ 36" STEAM DRUM
30'-0"
34 SPACES AT 3.3" • 9'-4.2"
3'-7.65"
5'-7.65"
34 SPACES AT 3.3" • 9'-4.2"
℄ 54" STEAM DRUM
℄ 36" MUD DRUM
51 SPACES ON ALTERNATE
6 3/8" & 5 7/8" CENTERS • 25'-6 3/4"
25'-0" BOILERS NO. 8 & 10
30'-0" BOILER NO. 7

Fig. 29. Section plan of the new steam-generating units. Section taken just above the economizer tube bundle

Steam enters a carbon-steel superheater inlet header for distribution to the superheater loops through 20 3¼ in. OD tubes connecting into the steam scrubber space of the feed drum. The first six loops are of ordinary grade C carbon steel; the seventh loop is of carbon molybdenum steel; the eighth and ninth loops which carry the hottest steam and receive the hottest gas are of 4 to 6 per cent chrome 0.5 per cent molybdenum alloy steel. The superheater outlet header is 13¾ in. OD ⅞ in. thick carbon molybdenum steel. Both superheater headers are located in a penthouse above the boiler where they are out of contact with the hot furnace gases.

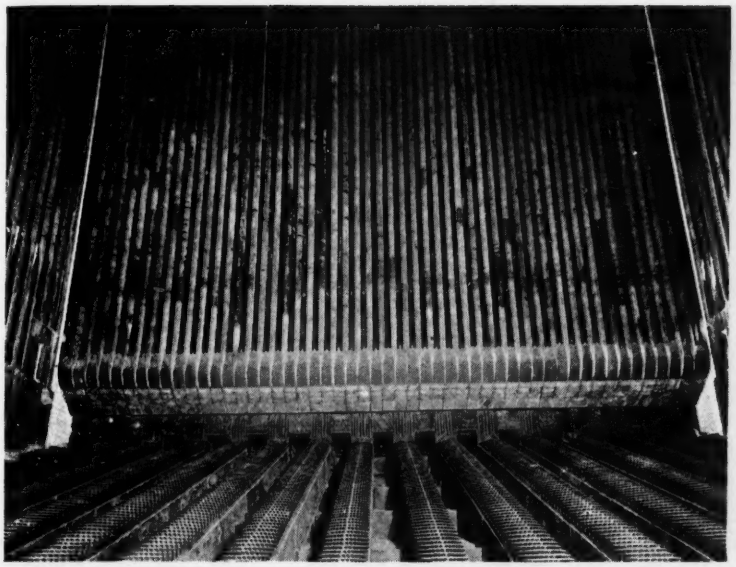
A novel method of constructing the by-pass partition walls was worked out for these units. At the superheater pass where gas temperatures approximating 2300 F prevail at high output, water-cooled partitions were made by installing a single panel of studded boiler tubes at either side of the by-pass and casting a ganister-clay mixture on them. Figures 36a and 36b show the upper and lower ends of the studded partition tubes before the wall was cast. The partitions in the rear boiler bank are of baffle tile bolted to the boiler tubes. In the arched space above the economizer tube bundle the partition walls consist of hanging panels of fire brick. In the economizer tube bundles the partitions are made up of steel flats each drilled to receive the tubes of one tube panel. Flats of adjacent panels are in contact at their edges, making a complete wall. Partitions in the economizer hopper are of steel plate. The by-pass dampers located in the wall between the economizer hopper and the air-heater inlet are operated by motors controlled from the boiler gage-board, which also carries a damper position indicator.

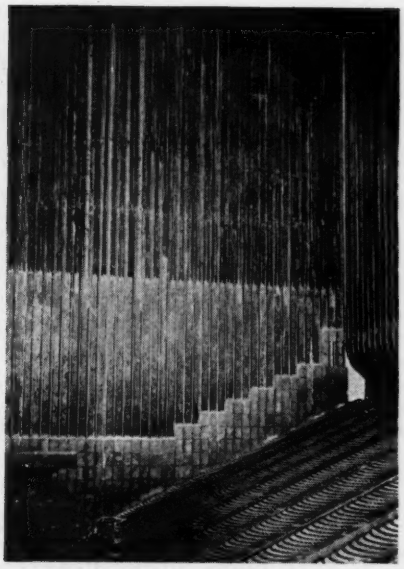
Economizer

Several features of the economizer design are worthy of mention in this account.

Heating surface totaling 18,300 sq ft per boiler consists of plain tubes arranged in 40 panels, 26 tubes high. Inlet and outlet headers are at the same end of the unit and are anchored to the steel work to prevent movement and vibration. Longitudinal expansion of the heating surface takes place in only one direction, i.e., away from the headers.

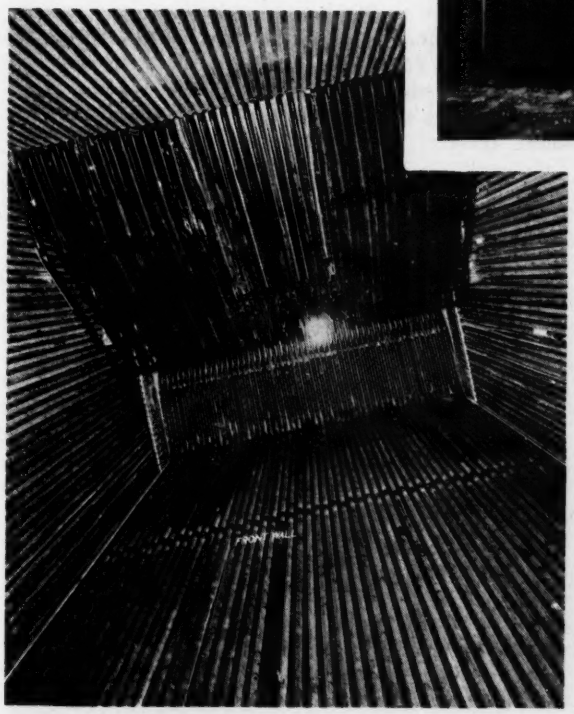
Joint leakage is eliminated by the use of welding. Tube holes in the headers are fitted with short nipples that are rolled in and welded. The outer end of each nipple and the end of each tube are upset to receive an internal backing ring over which the tube-to-nipple joint is welded. In addition to the welding at the headers, each panel of tubes is formed by butt welding, in sequence, the ends of tubes previously bent to hairpin shape and inserted through the superheater by-pass partition strips. Thus there are no mechanical joints whatsoever in the economizer, and no handholes in the headers. Should a tube split or leakage develop from any cause it probably will be

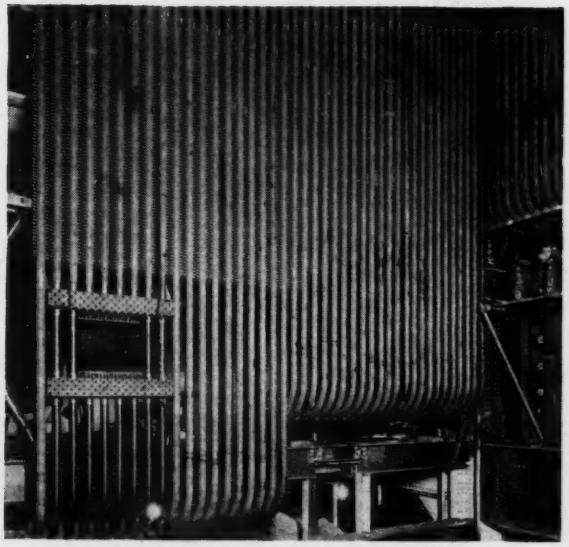




INTERIOR VIEWS OF DELRAY FURNACE FROM VARIOUS ANGLES

Fig. 30a, upper left, 30b, upper right, 30c, right. Front, side and rear furnace walls. Fig. 31. Lower left. Interior view of the furnace looking vertically upward. Fig. 32. Lower right. Furnace side wall during construction showing partially studded tubes





necessary to replace the entire panel in which the failure occurs.

The economizer is supported on beams underneath the unit with the steel partitions of the superheater by-pass serving also as intermediate support plates. The floating end of each economizer loop is supported by a pad welded to the loop and arranged to slide horizontally on a bracket attached to the steel work.

Construction of the refractory arch between the boiler outlet and economizer inlet presented an unusual problem because the gas temperature in the by-pass section approaches a value of 1600 F at maximum output, and, since the arch was to be made tight against air infiltration, any ordinary use of supporting steel would have been unsafe. Consideration of different designs of suspended and self-supporting arches led to a decision in favor of a flat arch using commercially available standard tile hung on steel supports, backed up with rock wool insulation, and finally covered with a welded-steel jacket. In the end sections of the arch which correspond with the superheater banks the gas temperature is reasonably low, and the tile are hung from steel pipes by means of special clips that engage a dovetail slot in the tile according to the arch manufacturer's standard design. In the by-pass section the tile are suspended on triangular-shaped tubes, especially made to fit the tile dovetail. The upper vertex of the triangular tube is welded to the web of a T-beam for reinforcement against deflection and to provide a simple means for attaching intermediate supports. Each triangular tube is cooled by induced ventilation, the lower end being open to atmosphere while the upper end is connected through a small pipe to the inlet of the induced-draft fan. In this way some 300 cfm of atmospheric air are passed through the supporting tubes in the by-pass section of each economizer arch. On test the temperature of the air-cooled tubes has been measured at about 400 F, which of course, is entirely safe. There is no infiltration of air through the arch into the main gas stream.

The completed arch is carried on structural steel anchored at the lower end and arranged to expand upward.

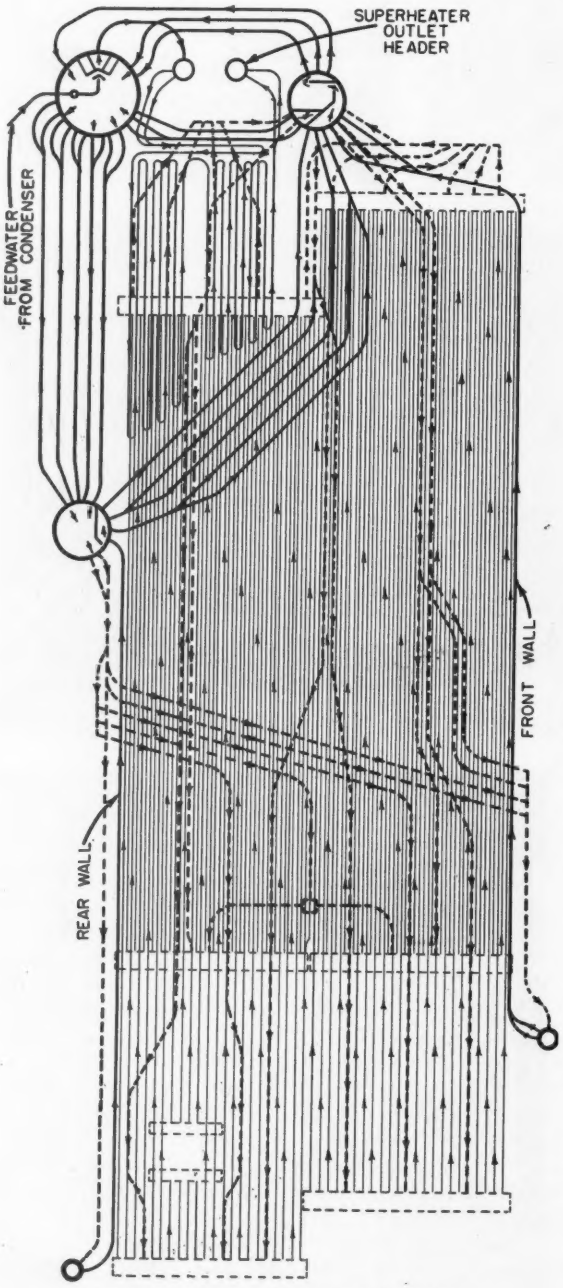


Fig. 33. Diagram of the boiler circulation system

Air Heater

The air heater is of conventional tubular design, each steam generating unit being fitted with two 15,100 sq ft banks of air-heating surface, i.e., 30,200 sq ft per boiler. Two forced-draft fans discharge separately into their respective sections of the air heater, but the air flow becomes equalized in an internal plenum chamber between the tube banks. From this chamber the flow again divides to pass through two ducts which enter the stoker plenum chamber from opposite ends of the stoker. Within the air heaters there are two parallel two-pass air circuits in each tube bank.

The heating surface consists of 960 steel tubes 2½ in. OD by 24 ft long, formed from steel plate rolled into cylinders and longitudinally welded. The tubes are expanded into both top and bottom tube sheets.

Integral Soot Blowers

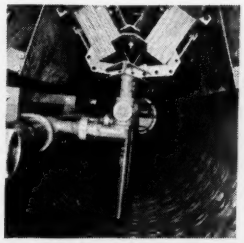
Effective cleaning of heating surfaces in the steam generating unit is as necessary as ever, or more so, not only to good efficiency but also to continuous operation of the unit over long periods of time. An integral-type soot blower developed for Conners Creek has met the requirements so well that its adoption for the new Delray Units was easily justified.

The soot blower element is a ¼ in. wall 1¼ in. OD steel tube, milled flat on one side and welded lengthwise to the back of a boiler tube. Small nozzles pointing in directions best suited for effective cleaning are welded into the soot blower element at appropriate intervals along its length.

There are four sets of soot blowers in each new

steam generating unit. Of these the first is at the superheater entrance where elements are welded to the back of each tube in the last (third) row of the first boiler bank, and, with nozzles blowing some horizontally and some vertically, are intended to clean the entire superheater bank. The second set of blowers cleans the rear boiler bank and is carried on the first row of tubes in that bank. The third set of soot blowers is installed at the top of the economizer where they blow vertically downward through the economizer tube bundle. The fourth and last group of elements is at the lower end of the air heater where one nozzle is provided for every four tubes and discharges vertically upward through the length of the tubes. It will be noted that all four sets of soot blowers discharge in the direction of the normal gas flow.

No permanently installed soot blowers are provided to clean the first boiler bank since the furnace temperature is relatively low and no slagging of the boiler tubes is anticipated when normal coal is used. The contingency of burning poor coal made it advisable to provide some means for cleaning the front bank, however, so a number of small doors were installed in the furnace wall to permit hand lancing the front bank of tubes if necessary.



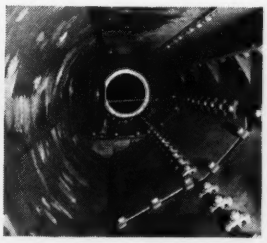


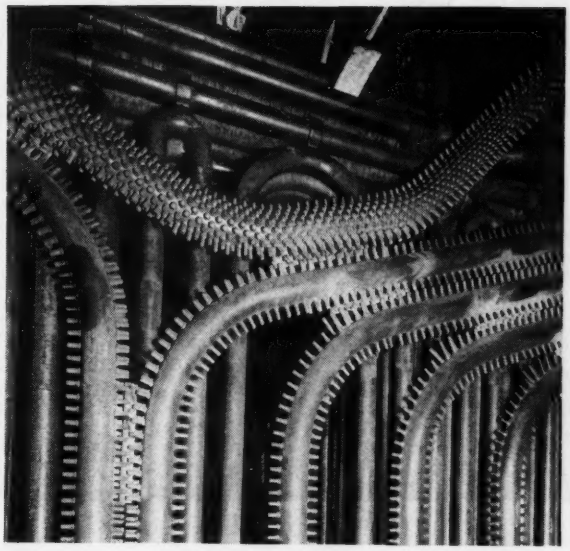
Fig. 34. Arrangement of the steam scrubber and spray heads inside the 54-in. diameter feed drum

Fig. 35. Arrangement of circulation baffles inside the 36-in. diameter steam drum

The soot blowing arrangements have not been entirely satisfactory to date and changes are going forward to effect better cleaning of the unit. Just what changes are made and how they work out will be reported, together with other operating experiences in the last installment of the series.

TABLE VIII—SUMMARY OF DESIGN PERFORMANCE OF STEAM GENERATING UNITS IN DELRAY EXTENSION

	Full load Rating		
Coal Burning Rate, lb per hr	16,000	34,000	44,000
Steam output, lb per hr	167,300	344,000	424,000
Steam pressure, psi g	865	865	865
Steam temperature, F	910	910	910
Feedwater temperature to economizer, F	375	375	375
CO_2 at superheater pass	14.80	16.15	16.60
CO at superheater pass	0.02	.16	.60
CO_2 at Boiler outlet	14.15	15.75	16.20
CO at Boiler outlet	.02	0.16	0.60
Furnace temperature, F	1950	2300	2400
Gas temperature leaving superheater, F	925	1080	1160
Gas temperature at boiler outlet, F	792	1036	1105
Gas temperature leaving economizer, F	436	498	530
Gas temperature leaving air heater, F	269	315	337
Air temperature leaving air heater, F	306	334	357



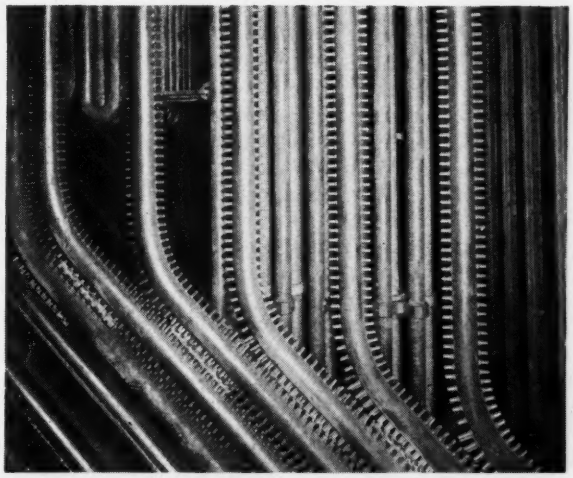
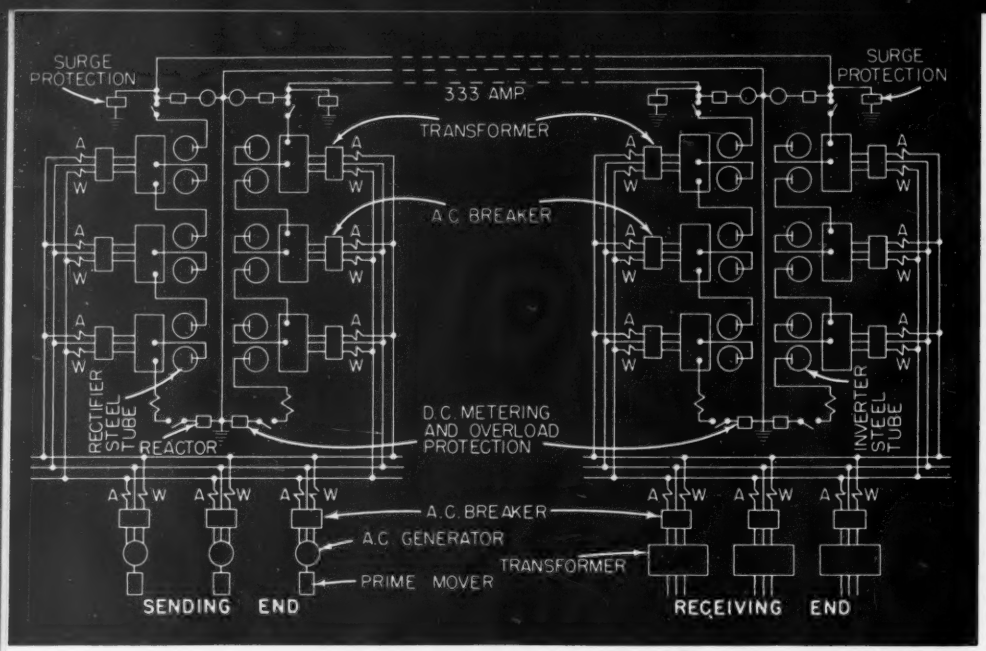


Fig. 36a, 36b. Upper and lower ends of the studded boiler tubes in the superheater by-pass partitions

CINDER DISPOSAL SYSTEM

Cinders collected in the refuse hoppers are too valuable to discard since they contain a high percentage of fixed carbon, but they do not burn well if introduced into the furnace intermittently in large amounts. Hence at Delray each refuse collecting point is continuously drained into the furnace through a rotating seal valve and welded steel duct. Collecting hoppers are provided just beyond the last boiler pass, again at the lower ends of the economizer and air heater casings, and also beneath the slotted scroll case of the induced-draft fan. The several refuse pipes enter the furnace through small rectangular openings in the back wall as shown in Fig. 31c and between the gas burners shown in Fig. 26.

Data are presented in Table VIII to show the performance for which the steam generating equipment is designed when using normal coal alone.



Electron

Part XXXVI

By

A. W. KRAMER

Fig. 1. Diagram of a projected 100,000 kw. d.c. transmission system

IT NOW BECOMES NECESSARY to begin to bring this long series of articles to a close. The author approaches this task with some trepidation and with considerable feeling of regret, for he has enjoyed writing the articles and in now terminating the series he is, more than ever, conscious of their shortcomings —there is still so much that could be told. But as anyone with even a remote knowledge of electronics knows, material on this subject is all but unending, and, to borrow a term from the mathematicians, to avoid making this an "infinite series," it becomes necessary to draw the line somewhere and bring the discussion to an end.

As a noted electrical engineer remarked recently, one of the most interesting things about electronics is the difficulty of keeping up-to-date. New developments transpire with such rapidity that they become obsolete almost before one is aware of them. It is not merely that new tubes and new circuits are different from the old ones but they are much more efficient and far less expensive. Not many years ago the highest transconductance in a receiving tube was about 2500 and the retail price was $9.00. Transconductance is a measure of tube efficiency.[1] When the 2A3 was developed the transconductance was raised to 5200. Then the 25L6 was brought out with a transconductance of 8200 and a retail price of $2.25. This is typical of what has happened in every branch of the electronic art.

During the very time that these articles have been appearing, many of the tubes and circuits referred to have become obsolete, and many developments in tubes and circuits made during this time have not even been mentioned. Take the "beam" power tubes, for example; insofar as we can recall, these tubes have not been mentioned. Nor has any reference been made to the "feedback" circuit developed by Black of the Bell Telephone Laboratories. Yet both of these developments are almost indispensable in modern electronic circuits.

[1]See Part XXIII, page 187, March 1938.

So, in these last few articles, if for no other reason than as a matter of record, we are going to discuss them in a general and somewhat informal way.

In the last six or eight articles we have considered almost entirely applications of the gas-filled type of tube. These "heavy-power" applications have been stressed because they give promise of important use in the power field—the field which readers of this publication are concerned with.

It must not be assumed, however, that the gas-filled tube is more important in the power plant field than the high vacuum type. As a matter of fact most of the applications of electron tubes in the power plant field have used tubes of the high vacuum type. The cases where thyratrons are used in exciters, voltage regulators, and motor control are still comparatively rare. In recent months the "ignitron" type of tube

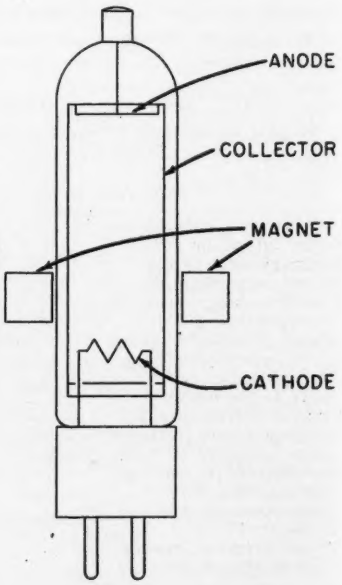


Fig. 2. The Permatron. With the addition of the collector and the external magnet it will be seen that the tube has the same structure as the ordinary hot cathode rectifier

Tubes—Principles and Applications

Cheer up! We will soon be finished. With just one more article following this one the Electron Tube series will be brought to a conclusion. In this article some loose ends are gathered up and given consideration, Beam power tubes, the Permatron and stabilized amplifiers being the principal topics.

has been used with good success in electron tube excitation systems for synchronous condensers but this work is being carried on almost entirely by one operating company.

Unquestionably, high power gas filled tubes will be developed which will find increasing use in all branches of the electrical industry including the power field. At the present time the proposed use of high voltage d.c. transmission is a topic of lively discussion. Although an experimental 27,000 v. line of this type has been in operation for over two years with good success, it is too early to predict the nation-wide use of such lines as has been proposed. At the same time it would be foolish not to admit that future development may make such lines possible. Electron tubes of the heavy power type naturally occupy an important place in these schemes.

In Fig. 1 is shown a diagram of a projected 100,000 kw. d.c. transmission system using mercury arc rectifiers and inverters. The interesting thing about this system, which has been suggested by Allis-Chalmers[2] is that it makes use of standard equipment available today. The system includes both conversion and inversion equipment, one transformer supplying two rectifiers. Thus, a total of six transformers, each rated at 16,666 kw. are required. In order to obtain the transmission voltage of 300 kv., 12 tubes—six connected in series between positive and ground and six between negative and ground—would have to be employed. All switching can be done on the a.c. side, and the switchgear in the high tension d.c. circuits is of the disconnecting type, provided only for operation without power on the line.

It is not the purpose here to enter into a discussion of the relative merits of d.c. and a.c. transmission but this circuit is presented to show where and how electron tubes fit into the d.c. transmission scheme. In the system shown grid controlled mercury arc rectifiers are proposed but of course the system could be operated using thyratrons or ignitrons. Indeed, a new tube known as the "Permatron" might find application.

The important point is, that if d.c. transmission should prove economically feasible and development in this direction continues, high power tubes of the mercury vapor type will be used in abundance.

[2]Possibilities of d.c. power transmission, by O. K. Marti, Allis-Chalmers Electrical Review, page, 5, December 1937.

The Permatron

A word about the "Permatron."[3] This is a new gas-filled control tube, similar to the thyratron, but in which the initiation of the discharge is controlled by an externally applied magnetic field. While there is nothing new in the principle of controlling an electron current by a magnetic field, comparatively little attention has been paid to the proper design of such tubes or to their application.

A diagram of a Permatron is shown in Fig. 2. In addition to the anode and cathode which are conventional, the bulb contains a cylindrical collector electrode which surrounds the discharge path. The controlling magnetic field is applied as shown through the poles of an electromagnet located outside the bulb.

[3]The Permatron—A Magnetically Controlled Industrial Tube. W. P. Overbeck. A paper presented before the American Institute of Electrical Engineers, New York, January 1939.

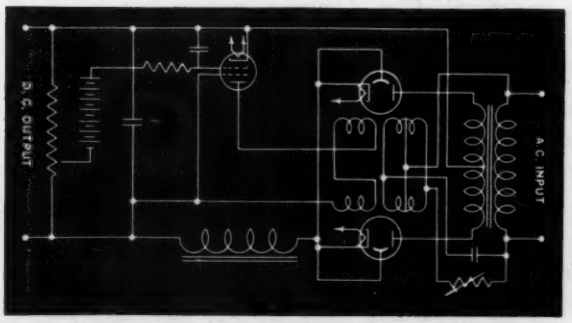


Fig. 3. Fundamental circuit diagram of a Permatron-controlled rectifier

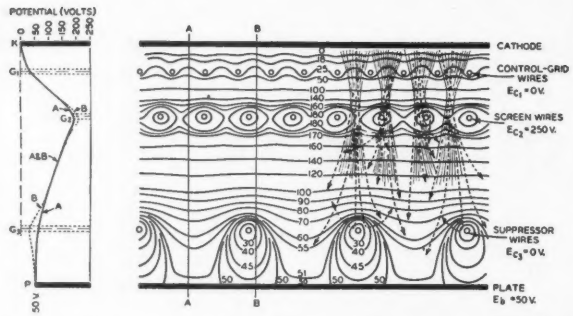


Fig. 4. Diagram showing the potential distribution and the path of electron travel in a suppressor-grid type of power pentode

Non-magnetic materials are used for all parts of the tube which might affect proper distribution of the magnetic field.

When a positive anode voltage and a magnetic field are applied to the Permatron, electrons emitted by the cathode are deflected and strike the collector. Due to the presence of the collector, which is usually maintained at a potential close to or equal to that of the cathode, this deflection takes place in a region of weak electrostatic field intensity and the electrons are removed from the discharge path before acquiring sufficient velocity to cause ionization. If the magnetic field is removed, the electrons proceed toward the anode, gaining velocity and producing ionization. Conductance continues at a low voltage drop between cathode and anode until the anode voltage is removed or reversed. Thus, the initiation of a heavy current discharge may be controlled by diverting electrons which represent but a minute portion of the same current. For each value of anode voltage there is a critical value of magnetic field intensity above which the discharge will not start.

The Permatron performs the same type of service as provided by thyratrons and ignitrons but it has characteristics which may give it preference over the two older types of tubes in certain cases.

First, the electromagnetic control may remain insulated from the tube and its associated power circuit. Secondly, control of the Permatron is independent of the polarity of the magnetic field. Finally, it produces unusual phase-shift control characteristics which are useful in certain instances.

Since the Permatron may be controlled by moving permanent magnets new combinations of moving machinery and these tubes open up new fields of application. An example of this is in the problem of elevator leveling where permanent magnets might be mounted on the cage.

Another advantage which is particularly important in communication circuits is the lack of reaction between the tube and the control magnet. The control impedance remains the same and is linear whether the tube is conducting or not. Operation of the control from extremely low voltages is possible, though heavy control currents are required. The tube shown in Fig. 2 for example can be controlled by a voltage lower than 6 microvolts when a single turn control magnet is used.

A circuit using Permatron tubes is shown in Fig. 3.

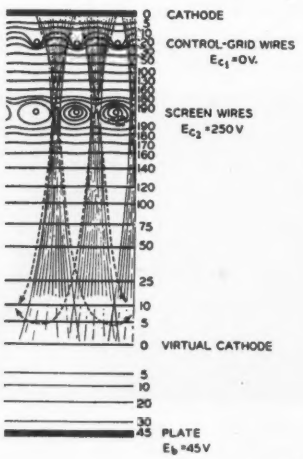


Fig. 5. Potential field of type 6L6 beam power tube

Beam Power Tubes

In one of the foregoing paragraphs, the term beam power tubes was used. Beam power tubes[4] are new types of high vacuum tubes which have been developed in recent years, as a result of continued study and research on the mechanism of tube operation. They were developed in the laboratories of R. C. A.

The theory of operation of beam power tubes is rather complex but the fundamental difference between these tubes and conventional high vacuum tubes can be explained by the diagrams shown in Figs. 4 and 5. The first of these, Fig. 4, is a diagram of a conventional suppressor-grid tube. In such a tube the wires of the various grids are disposed in random fashion, that is, no attempt is made to "register" the various grids so as to align the grid wires in any way. Consequently, electrons from the cathode and passing between the wires of the control grid may or may not be propelled head-on against the wires of the screen grid. Even those electrons which are not captured by the screen grid may be deflected to such an extent as to be turned back to the screen grid by the repelling influence of the suppressor grid.

Figure 5 is a similar diagram for a beam power tube. The beam power tube is the first tube in large quantity production to utilize grids in register. At present, the alignment is held to within 0.004 in. for all grid wires.

As shown in Fig. 5, the control grid wires have a focusing effect upon the electrons passing between them. This convergence of the electron beams is such that the narrowest portion of the beams occurs between the wires of the screen grid. As a consequence all of the electrons passing between the wires of the control grid also pass between the wires of the screen grid. Each group of electrons formed by a pair of screen grid wires forms a "beam" which is directed to pass between the screen grid wires.

The formation of these beams has another effect. At a point far beyond the screen grid, as the electrons decelerate, the beams diverge and meet. At this point the electrons approach a region of zero potential. This region therefore has the properties of a

[4]Beam Power Tubes. By O. H. Shade. Proceedings of the Institute of Radio Engineers. Feb. 1938, p. 137.

cathode though there is no actual cathode structure present. Hence, this region is known as the virtual cathode and acts to repel electrons formed by secondary emission at the plate. The action is that of a suppressor grid.

Tubes built along these lines have very high efficiency and since their appearance in 1936 they have had wide application. The important point to remember is that in these tubes, directed beams are formed when the entire length of all screen wires in the electron current is positioned in the electrical shadow of the control grid wires. The actual tubes have other refinements—beam confining plates, properly chosen grid wires, side rods and electrode shapes, but if these are properly incorporated, electron streams of nearly ideal properties are obtained. Naturally they are applicable to all types of circuits where high efficiency and high sensitivity are important.

Feedback in Amplifier Design

One of the most important developments in amplifier design in recent years is the use of stabilized feedback as developed by H. S. Black of the Bell Telephone Laboratories.

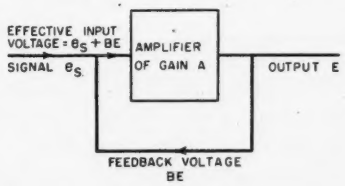


Fig. 6. Diagram showing the principal of negative feedback

The performance of the ordinary amplifier, especially when high degrees of amplification are necessary, is seriously affected by voltage fluctuations and slight changes in the characteristics of tubes and circuit constants due to age or temperature as well as other factors. It was, therefore, necessary in most cases to limit the amount of amplification in order to reduce the effect of these factors to a minimum.

All this was changed, however, with Black's revolutionary development of feedback. In our study of oscillating circuits and amplifier circuits one aspect of feedback was considered—how by feeding a portion of the output current back into the input of an electron tube circuit sustained oscillations could be generated. This, it was shown, was the basis of all radio transmitters, but when such transfer of energy took place spontaneously in amplifier circuit, the result was disastrous insofar as performance was concerned and neutralizing schemes were necessary.

However, by building an amplifier whose gain is made deliberately, say 40 decibels, higher than necessary (10,000 fold excess on energy basis) and then feeding the output back to the input in such a way as to throw away the excess gain, H. S. Black[5] of the Bell Telephone Laboratories found it possible to effect extraordinary improvement in constancy of amplification and freedom from non-linearity. By employing this feedback principle, amplifiers have been built and used whose gain varied less than 0.01 db. with a change in plate voltage from 240 to 260 v.

It is far from a simple proposition to employ feedback in this way because of the very special control required of phase shifts in the amplifier and feedback circuits, not only throughout the useful frequency band but for a wide range of frequencies above and below the band. Unless these relations are maintained singing will occur, usually at frequencies outside of the useful range. Once having achieved a design, however, in which proper phase relations are secured, experience has demonstrated that the performance obtained is perfectly reliable.

The principle of the feedback amplifier is shown in Fig. 6. Regeneration is introduced by superimposing upon the amplifier input a fraction B of the output voltage E, so that the actual input to the amplifier consists of the signal voltage e_s plus the feedback voltage BE. Since the output voltage E is necessarily A times the voltage actually applied to the amplifier input, $E = A(e_s + BE)$.

Without attempting to present the mathematical proof, which is rather complex, it can be stated here that the feedback voltage B opposes the input voltage in phase. The product of the amplification factor A and the feedback voltage B is called the feedback factor and represents the amplitude of the voltage superimposed upon e_s compared with the actual voltage applied to the input terminals. Thus if AB = 50, then for each millivolt existing between the input terminals, and, if the feedback is negative, a signal of 51 millivolts will be required to produce one millivolt at the input.

If the feedback factor is large the effective amplification depends only upon the fraction B of the output voltage that is superimposed upon the amplifier and is *substantially independent of the gain actually*

(Continued on p. 345)

[5]Stabilized Feedback in Amplifiers, p. 114, January 1934 Proceedings of the American Institute of Electrical Engineers.

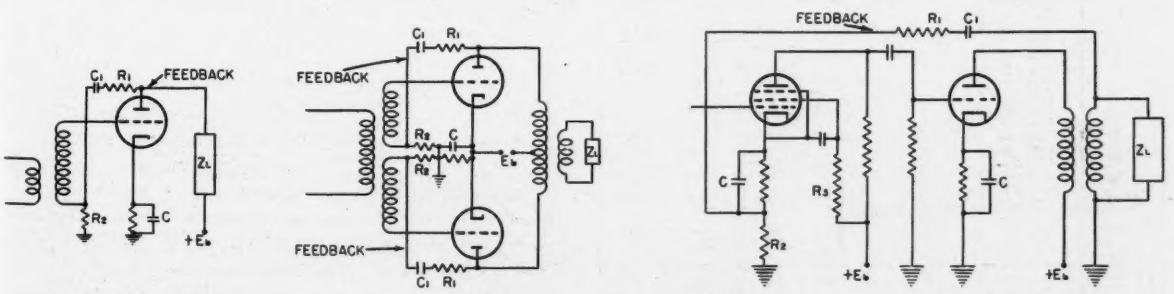


Fig. 7. Amplifier circuits using negative feed back

Ratings Tables for Leather Belting

BY L. H. SKOUGOR
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IN THE PAST, the user and purchaser of leather belting has been left largely on his own in designing belting for individual applications, and few engineers have had the time and facilities to segregate, from the numerous publications over the past decade, what can be considered a reliable and yet economical basis for leather belt rating. In many instances existent publications were at some disagreement as to what constituted good belting practice, and many theories set forth in older publications have been revised and disproved through practical application.

The long and deep felt need for belt ratings, by some universally recognized authority for the leather belt capacities, has recently been met by the A. L. B. A. in the publishing of its horsepower rating tables. These new tables make it possible for the designer and purchaser to set up his own specifications rather than segregate them from a number of recommendations from many individuals who might be competitively involved. The tables are based on the performance of modern and up-to-date belting correlated from scientifically measured tests and field data and thus are not based on one particular theory.

Table I. Horsepower ratings per inch of width for oak tanned flat leather belting for belt speeds up to 6000 f.p.m. For speeds higher than this consult a leather belting manufacturer. These figures should be used in conjunction with the pulley size and service correction factors from Tables II and III as shown by Ex. I and 2. The * in connection with thickness figures refers to the notes in Table IV

BELT SPEED FEET PER MIN.	SINGLE PLY		DOUBLE PLY			TRIPLE PLY	
	*11/64"	*13/64"	*18/64"	*20/64"	*23/64"	*30/64"	*34/64"
	MEDIUM	HEAVY	LIGHT	MEDIUM	HEAVY	MEDIUM	HEAVY
600	1.1	1.2	1.5	1.8	2.2	2.5	2.8
800	1.4	1.7	2.0	2.4	2.9	3.3	3.6
1000	1.8	2.1	2.6	3.1	3.6	4.1	4.5
1200	2.1	2.5	3.1	3.7	4.3	4.9	5.4
1400	2.5	2.9	3.5	4.3	4.9	5.7	6.3
1600	2.8	3.3	4.0	4.9	5.6	6.5	7.1
1800	3.2	3.7	4.5	5.4	6.2	7.3	8.0
2000	3.5	4.1	4.9	6.0	6.9	8.1	8.9
2200	3.9	4.5	5.4	6.6	7.6	8.8	9.7
2400	4.2	4.9	5.9	7.1	8.2	9.5	10.4
2600	4.5	5.3	6.3	7.7	8.9	10.3	11.0
2800	4.9	5.6	6.8	8.2	9.5	11.0	12.1
3000	5.2	5.9	7.2	8.7	10.0	11.6	12.8
3200	5.4	6.3	7.6	9.2	10.6	12.3	13.5
3400	5.7	6.6	7.9	9.7	11.2	12.9	14.2
3600	5.9	6.9	8.3	10.1	11.7	13.4	14.8
3800	6.2	7.1	8.7	10.5	12.2	14.0	15.4
4000	6.4	7.4	9.0	10.9	12.6	14.5	16.0
4200	6.7	7.7	9.3	11.3	13.0	15.0	16.5
4400	6.9	7.9	9.6	11.7	13.4	15.4	16.9
4600	7.1	8.1	9.8	12.0	13.8	15.8	17.4
4800	7.2	8.3	10.1	12.3	14.1	16.2	17.8
5000	7.4	8.4	10.3	12.5	14.3	16.5	18.2
5200	7.5	8.6	10.5	12.8	14.6	16.8	18.5
5400	7.6	8.7	10.6	12.9	14.8	17.1	18.8
5600	7.7	8.8	10.8	13.1	15.0	17.3	19.0
5800	7.7	8.9	10.9	13.2	15.1	17.5	19.2
6000	7.8	8.9	10.9	13.2	15.2	17.6	19.3
Minimum Pulley Diameters — Belts Under 8" Wide	3"	5"	6"	8"	12"	20"	24"
Minimum Pulley Diameters — Belts 8" & Over Wide	5"	7"	8"	10"	14"	24"	30"
These are the minimum allowable pulleys for the above thickness belts.							

Data Based on Tests

TABLE 1 lists horsepower transmission capacities for belts 1 in. in width at varying speed with the same given large size pulley used throughout the tests. The tests were run at Cornell University by Ralph Jones on the most up-to-date and modern equipment available in the country. All variables were carefully measured rather than resorting to theoretical shortcuts and computations. It was a surprising thing that many of the existant formulas and theories concerning these variables were found to be inaccurate in checking with practical measurement. The figures in this table do not represent peak load ratings, but are based on proper tensions and factors of safety, so that when corrected through the factors in Tables II and III, a properly designed drive will result.

It will be noted that the horsepower transmitted in inch of width increases with the speed of the belt.

With the work in Table I completed, it was necessary to establish a factor to compensate for the variables introduced, such as changing effective area. These same tests were therefore run with varying

Example I. Typical calculation for determining the width of belt required for a specific installation

PROBLEM: Determine capacity of 8" Heavy Double Belt on following drive—
Lineshaft— 200 R.P.M., 48" diameter x 12" face cast iron pulley
Fan— 600 R.P.M., 16" diameter x 12" face cast iron pulley, requiring 35 H.P. at this speed.
Conditions—Tight side above, 16 foot centers, drive nearly vertical, 8 hour per day operation, exhausting from woodworking shop, dusty conditions.

SELECTION OF FACTORS:
Belt Speed $\frac{48 \times 3.14 \times 200}{12} = 2500$ F.P.M.
From Table I, HEAVY DOUBLE BELT is suited for 16" diameter pulley.
From Table I, HEAVY DOUBLE BELT will transmit 8.55 H.P. per inch of width at 2500 F.P.M.
From Table II, FACTOR for center distance and small pulley diameter = .80
From Table III, Atmospheric condition .7
Angle of center line .8
Pulley material 1.0
Service 1.0
Peak load 1.0

CALCULATION: 8. x 8.55 x .80 x .7 x .8 x 1.0 x 1.0 x 1.0 = 30.6 H.P.
Therefore, belt not suited for 35 H.P. load.
NOTE: This belt can be used if any one of the following changes are made—
1. Use fibre pulley on fan.
2. Reduce angle of drive to 60 degrees from horizontal
3. Protect drive from dust.
4. Increase pulley diameters to 60" and 20".
If it is not practical to change the drive, use a 10" HEAVY DOUBLE BELT.

Table II. Correction factors for center distance and small pulley diameters to use with the data from Table I. Consider gravity idler and pivoted motor drives with tight side of the belt next to the pivot point as having 25 ft. centers. For pivot base drives where tight side of the belt is away from the pivot point, do not use these tables but consult a leather belting manufacturer

Diameter Small Pulley Inches	CENTER DISTANCE IN FEET															
	Up to 4'		6'		8'		10'		12'		15'		20'		25' & Over	
	Tight Side		Tight Side		Tight Side		Tight Side		Tight Side		Tight Side		Tight Side		Tight Side	
	ABOVE	BELOW	ABOVE	BELOW	ABOVE	BELOW	ABOVE	BELOW	ABOVE	BELOW	ABOVE	BELOW	ABOVE	BELOW	ABOVE	BELOW
3"	.45	.45	.46	.47	.47	.48	.47	.49	.48	.50	.49	.52	.48	.54	.48	.55
4"	.53	.53	.54	.55	.55	.57	.56	.59	.57	.61	.58	.63	.59	.65	.59	.66
5"	.59	.59	.60	.62	.62	.64	.63	.66	.63	.68	.65	.70	.66	.72	.66	.74
6"	.62	.62	.63	.65	.65	.68	.66	.70	.67	.72	.68	.74	.69	.76	.70	.78
8"	.66	.66	.67	.69	.69	.72	.70	.74	.71	.76	.72	.78	.73	.80	.74	.82
10"	.68	.68	.70	.71	.71	.74	.73	.77	.73	.79	.75	.81	.76	.83	.77	.85
12"	.70	.70	.72	.74	.73	.77	.75	.79	.76	.81	.77	.83	.78	.86	.79	.88
15"	.73	.73	.74	.76	.76	.79	.77	.82	.78	.84	.80	.86	.81	.89	.82	.91
18"	.75	.75	.76	.78	.78	.81	.79	.84	.80	.86	.82	.89	.83	.91	.84	.93
24"	.77	.77	.79	.81	.81	.84	.82	.87	.83	.89	.85	.92	.86	.94	.87	.96
30"	.79	.79	.81	.82	.82	.86	.84	.89	.85	.91	.87	.94	.88	.96	.89	.98
36"	.80	.80	.82	.84	.83	.87	.85	.90	.86	.92	.88	.95	.89	.98	.90	1.00

pulley diameters and center to center distances resulting in the correction factors as shown in Table II. These tests were in the same manner run through a practical and yet scientific series of measurement rather than using any theoretical formulas or short cuts. It will be noted that when gravity idlers and pivoted motor bases are used it was found that the factor for center line distances of 25 ft. and over can be substituted for the effect of controlled tensions in pivoted bases and increased affective area of the gravity idler.

Service Factors

Requirements of various industries often introduce adverse conditions that must be taken into consideration, and their values cannot be extracted from the factors as represented in a laboratory test. It is necessary to belt a drive for the peak loads that will be encountered. The nameplate rating of a motor is not a true indication of the peak loads that may be met and the correct overload capacity and torque characteristics of various motors are not always available to the millman.

Comparison of Data

To insure against under-belting and premature belt failure, overload ratings of the motor, atmospheric conditions, service, etc., must be brought into the calculation to assure satisfactory belt performance. It is fully realized that conditions in isolated cases exist which may not be covered by this table, and exceptions must be made in those instances. A caution should be made that in no instance should a belt rating be taken from any one table without using the proper correction factor from the other two to compensate for the individual condition surrounding the particular application.

In Fig. 1 the available leather belting horsepower curves have been plotted. They have been compiled from practically all existing manufacturers and authorities. It will be noted that the curve, as rep-

Example 2. Typical calculation for determining the capacity or rating of given belt for a specified service

PROBLEM: Select belt for following drive—

Motor— 10 H.P. 1750 R.P.M., line start, induction
Pulley 6" diameter x 6¾" face, fibre.

Compressor—Started automatically against pressure
Pulley 30" diameter x 6½" face.

Conditions— Tight side of belt below, pulleys 6 feet center to center, center line approximately horizontal, important refrigeration service, normal atmospheric conditions.

SELECTION OF FACTORS:

Belt Speed $\frac{6 \times 3.14 \times 1750}{12} = 2750$ feet per minute

From Table I, LIGHT DOUBLE BELT suited for 6" diameter pulley

From Table I, LIGHT DOUBLE BELT will transmit 6.7 H.P. per inch of width at 2750 F.P.M.

From Table II, FACTOR for center distance and small pulley diameter = .65

From Table III, Atmospheric condition 1.0

Angle of center line	1.0
Pulley material	1.2
Service	.8
Peak load	.6

CALCULATION: $\frac{10}{6.7 \times .65 \times 1.0 \times 1.0 \times 1.2 \times .8 \times .6} = 3.99"$

Therefore, use 4" LIGHT DOUBLE BELT

Table III. Service correction factors to be used with the data from Table I

Atmospheric Condition	Clean, scheduled maintenance	1.2
	Normal	1.0
	Oily, wet or dusty	.7
Angle of Center Line	Horizontal to 60 degrees from horizontal	1.0
	60 to 75 " " "	.9
	75 to 90 " " "	.8
Pulley Material	Fibre on motor and small pulleys	1.2
	Cast iron or steel	1.0
Service	Temporary or Intermittent	1.2
	Normal	1.0
	Important or continuous	.8
Peak Loads	Light, steady load such as: steam engines, steam turbines, Diesel engines, and multi-cylinder gasoline engines	1.0
	Jerky loads, reciprocating machines such as: normal starting torque squirrel-cage motors, shunt wound D. C. motors, and single cylinder gasoline engines	.8
	Shock and reversing loads, full voltage start such as: wound rotor (slip ring) motors, synchronous motors	.6

Table IV. Thickness specifications adopted by the A.L.B.A. for flat leather beltings

Medium, Single Ply, 11/64" Average Heavy, Single Ply, 13/64" Average	"All thicknesses in this table are average thickness in inches, and should be determined by measuring 20 coils and dividing this total by the number of coils measured. In rolls of belting containing less than 20 coils, the average thickness should be determined by measuring all the coils in the roll. Allowable tolerances for all thicknesses plus or minus 1/64th inch from above averages."
Light, Double Ply, 18/64" Average Medium, Double Ply, 20/64" Average Heavy, Double Ply, 23/64" Average	Uniformity: No point in single belting shall be more than 3/64" thicker or more than 2/64" thinner than the average thickness. With doubles, the tolerances shall be 2/64" thicker or thinner than the average.
*Medium, Triple Ply, 30/64" Average *Heavy, Triple Ply, 34/64" Average	
*TRIPLE PLY: These are averages for general usage. Most triple ply belts are usually constructed for particular drive conditions. *Tolerances for Single and Double Ply Belts do not apply.* Consult a Leather Belting Manufacturer for specific information concerning thickness and construction of 3 Ply Belts.	

resenting the factors given in Table I, falls by chance as a fair average of these curves. The curves that fall below the A.L.B.A. curve do not necessarily mean that more conservative figures have been used. These curves represent the rating as a result of Table I, and are conducted on large size pulleys. In many cases when the correction factors are applied the A.L.B.A. curve actually will fall below these curves for particular drives.

For Speeds Above 6,000 ft. per min. or for Special Conditions

A limitation is necessarily set in the scope of tables of this type, and where speeds over 6000 ft. per min. are reached, a leather belting manufacturer should be consulted. This same applies in cases where a pivoted base is installed with the tight side away from the pivot point where special conditions exist.

The A.L.B.A. renders a consulting engineering service to users of leather belting. This is a matter of some importance to men confronted with transmission problems for as a result of research and experience conditions are being met today by leather belting that were, some years back, beyond the limitations of the product.

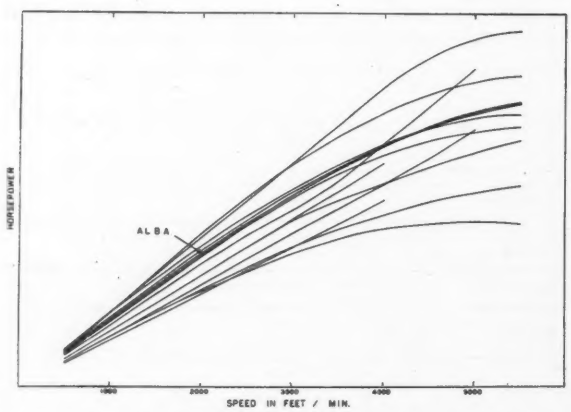


Fig. 1. Rating data collected from various sources compared with the A.L.B.A. recommendations. The reasons for the discrepancies are explained in the text

Welding Developments

IN OXYACETYLENE welding new procedure is being adopted, the torch flame being pointed backward toward the completed weld and welding rod held between the torch and weld. Manipulation is simplified and width of vee reduced from 90 deg. to 70 deg.

For walls over ⅜ in. thick, so large a pool of molten metal must be maintained, 1½ to 2 in. diameter on ¾-in. walls, that speed and weld quality may be reduced. Multilayer welding has been developed to improve conditions, each layer being not over ¼ in. thick. Field experience shows saving in cost of labor and material of 15 to 25 per cent with improvement in quality of weld. Preheating may be used to speed up welding if desired, but is not essential. Final layer should be deposited above the level of wall surface to insure maximum heat-treating benefit to lower layers.

For alloy steels such as carbon molybdenum, used for high pressures and temperatures (900-1400 lb. sq. in. and 900-1100 deg. F.) the welding rod should be the same analysis as the steel in pipe walls. With this, tests indicate that the welds have the same physical properties as to strength, and stretch as the walls themselves.

Stress relieving is required for wall thickness ¾-in. or more and service temperature over 250 deg. F. In the shop, this can best be done by furnaces. In the field, electric coil heating has been used but equipment is costly. Portable furnaces, fired with city or natural gas, have been successful. Oxy-acetylene torches are popular because of portability and quickly available high heat. A method used on large extra heavy pipe was to heat the pipe with torches to 1450 deg. F., then wrap the joint with asbestos, and plug the pipe ends and allow to cool slowly. Tests of the result showed good grain refinement in the weld, increased ductility and little loss in tensile strength.

Fittings for Welding

For butt welding, the angle of bevel has been reduced to 37½ deg., as the narrow groove saves time and material.

For 2-in. pipe and smaller, butt welding the thin wall has required care to avoid burning through, and socket welding fittings are coming into use. Pipe slips into the socket a short distance and a fillet weld is made.

For flange fittings, butt welding with improved hubs avoids the warping of the flange face sometimes encountered with a slip-on flange, welded at the inner end of the pipe. To insure using the right fitting for each job, size and standard is stamped into the side of each fitting. Also to ensure proper alinement, center lines are machine marked on elbows so that proper position may be accurately determined.

To save time lining the fitting up concentric with the pipe end, a centering ring is now forged on the fitting, which supports the pipe end ready for welding, ensures accurate alinement and strengthens the joint. It acts as a backing-up ring, so that the weld extends to the bottom of the joint without danger of burning through or formation of any projections, yet the ring is so small that there is no measurable friction loss of pressure.

Power Losses Fade Out Under Surveys

Graphic Records Play Important Part in Economical Operation of Industrial Plant

By K. B. HUMPHREY

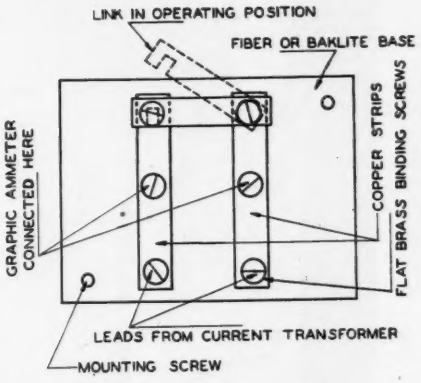


Fig. 1. Graphic meter connector

A PERIODICAL survey of the power taken by different motors around the plant, will, in most cases, show where substantial saving can be made. A power survey will reveal whether or not the motor is overloaded or underloaded, and either condition is costly in one way or another. In the case of an overloaded motor the result may be a burn-out or perhaps only a wasteful use of power which may be corrected in the machine or machines being driven. An underloaded motor is inefficient, has a low power factor (if an induction motor), and is likely to increase the demand charge. Either condition is. in most cases, correctable without great expense and the savings will pay for the changes needed.

It is not at all necessary to purchase an elaborate set of instruments in order to get a fairly comprehensive idea of the power each motor is taking. In many cases the proper instruments can be borrowed for a short period. The best and really the only necessary instrument is a graphic ammeter. Some industrials go in for surveys in a rather handsome way and get a full set of instruments including voltmeters, ammeters, wattmeters, etc., and have them all mounted on a portable truck so that by the proper hookup with the supply mains any and all data may be obtained.

The amount of current taken by a motor is the limiting factor in the operation of any motor and if by inspection it is suspected that the high current values are due to power factor or low voltage, then it is necessary to use other instruments besides the ammeter. For routine checking, however, a graphic ammeter will give a good indication whether things are going rightly. The graphic ammeter should be one with a 5 amp. maximum reading. Then by the use of a correctly sized current transformer the ammeter may be used in any circuit. In most cases the switchboard instruments on 2300-v. circuits operate with a 5 amp. maximum as do many of the watthour meters.

Where this type of circuit is available it is possible to hook into the secondary of the current transformer very easily. It is also possible to purchase a current transformer with a split core which may be placed around the wire leading to the motor. This is the simplest arrangement of all. I have found it practical to make a break-in for the graphic meter as shown in Fig. 1. It is only necessary to use three copper strips, two of which have three holes tapped for a flat head brass binding screw. and the third with two holes in it. The three strips are mounted as shown on a piece of fiber or bakelite so that the whole assembly can be mounted conveniently.

When it is desired to connect in the meter, the leads are first fastened to the two lower screws and then the short circuiting bar is removed. This makes it possible to connect the meter without opening up the circuit. The copper bars were made from some old switches

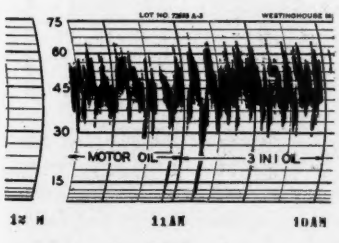


FIG. 2

Fig. 2. Chart showing the effect of using different kinds of oil in the dash pot

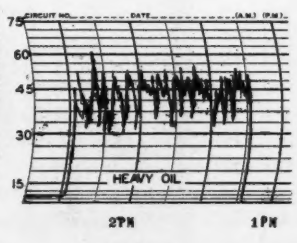


FIG. 3

Fig. 3. Chart showing record of same load as in Fig. 2 but using a heavier oil in the dash pot

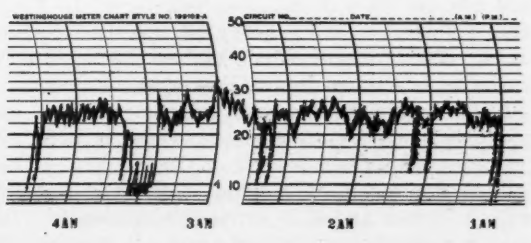


FIG. 4

Fig. 4. Graphic meter chart showing the load on a 125-hp. synchronous motor loaded satisfactorily

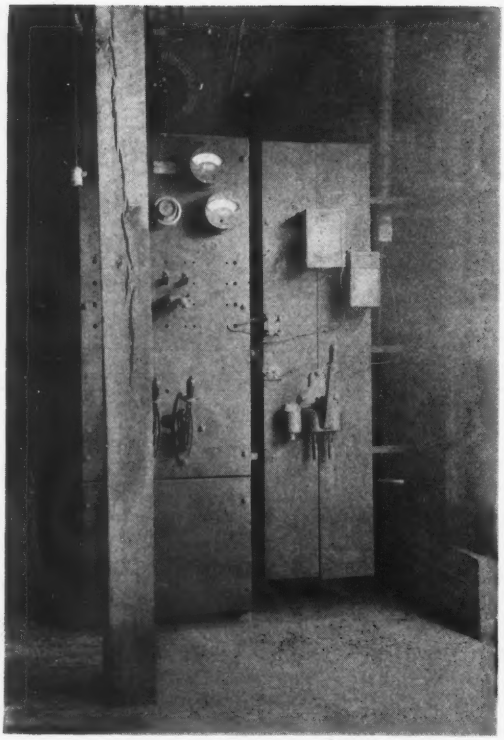


Fig. 5. Graphic meter with break-in device

which had been discarded. This idea has been used wherever a watthour meter happened to be in the circuit supplying an individual motor or where a synchronous motor was to be tested which had an ammeter on the starting panel. The accompanying photograph, Fig. 6, shows the graphic meter hooked in directly on the watthour meter current transformer circuit before it was decided to make a more extensive survey of all the motors in the plant.

Dash Pot Oil

In using the graphic ammeter a great deal of the value of the readings may be lost if the proper dash pot oil is not used. The graphs shown in Figs. 2 and 3 illustrate this point. They were both taken on the same circuit and under similar conditions. In Fig. 2 two different oils were used, ordinary 3-in-1 at first and then ordinary motor lubricating oil. The motor oil being slightly heavier the swing was not quite so bad but not by any means satisfactory. In Fig. 3 is shown a chart where a heavy oil was used equivalent to No. 600. Of course it is seldom that such a rapid variation of current input takes place in a circuit, but a little experimentation with different oils will give a readable chart. With a needle which is not damped enough, trouble will be had in the ink flow. The ink will all run out in blobs which have to be mopped up with a blotter and it is impossible to use the roll for taking care of the recorded chart. It will be noticed that the average value of the current is shown but without the extreme momentary peaks.

Figure 3 was taken on a circuit having the following motors: one synchronous 2200-v. motor of 375 hp., one induction motor, 2200-v. of 40 hp., one 220-v. 20 hp. and two 220-v. 2 hp. motors. The full load current of the synchronous motor is about 70 amp. and the chart shows a maximum of about 62 amp. for the whole load, which indicated that the large synchronous motor was considerably underloaded. Without much trouble it is possible to drive the load carried by the 2200-v., 40 hp. and the 220v., 20 hp. motors by means of belts connected to the main drive run by the large motor. Later this change will no doubt be made. In this way the efficiency of the department can be considerably increased as far as power consumption goes. Besides getting better efficiency on the synchronous motor, the losses of the two other motors will be eliminated, and less leading current will have to be supplied to get a high power factor with another gain in efficiency. This is just one illustration of a case where a power survey brought to light a condition in which a distinct saving could be obtained. In many cases where a motor is underloaded, especially an induction motor, it will pay to substitute a smaller motor and the power survey will give a good indication of what size motor should be substituted. In a large plant it is sometimes possible to shift motors about so that each one will get a proper load. In other cases where machines are driven in groups not too widely separated it is possible with a little regrouping to load up the motors properly. An underloaded squirrel cage motor has a very poor power factor and in any case where there is a power factor clause in the contract a change may be of decided advantage.

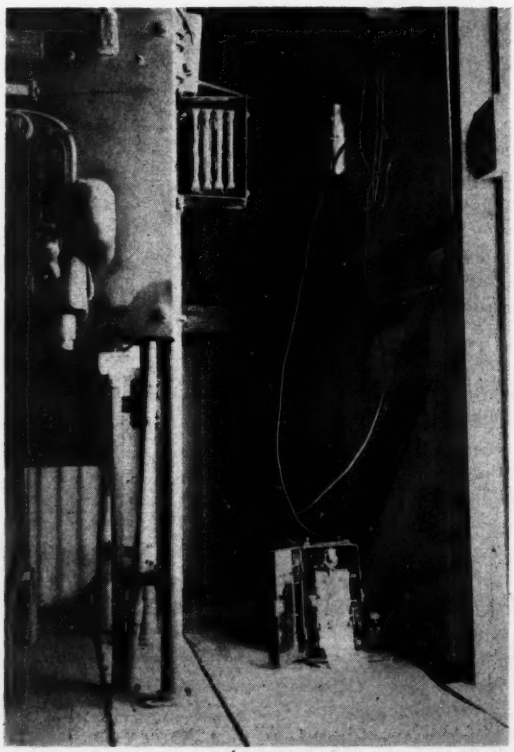


Fig. 6. Graphic meter hooked up to current transformer for recording current to a department

Figure 4 shows a chart taken from a single synchronous motor drive of 125 hp., 2200-v. with a full load current of 34 amp. It will be seen that the load does occasionally go up to this value, but for most of the operating period the current remains between 20 and 30 amp. In this case, however, the load is likely to be slightly heavier when a different product is being run and the operation is considered to be satisfactory. It would not do to have the load much greater because the variations might at times be enough to throw out the breaker.

Overloaded Motor

The graphic meter will also show up an overloaded motor and tell exactly how long the peaks last. In one case where a motor was well overloaded, the fact that it was overloaded was indicated by overheating. It was apparently pulling the same machinery with the same load that had always been on. By looking the installation over thoroughly it was discovered that a couple of the timbers supporting the line shaft had rotted at the floor line and that the shaft was badly out of line. By realigning the shaft, the motor was able to pull the load easily. Such a condition would have been discovered at a much earlier date had periodic power surveys been undertaken. While it would be impossible to estimate what actual saving would have been made it is certain that there would have been considerable as the shafting must have been getting worse and worse for a considerable time before it was discovered. When cases of overload are found it is sometimes possible to relieve the load by such methods as outlined above. In other cases it may mean a new motor with sufficient capacity being substituted. It is not always advisable to take an indication of overload from the ammeter alone as a low power factor on the system will tend to increase the current readings. If, after a thorough inspection of the driven machinery, line shaft, and bearings, no cause for the overload can be determined it is a good plan to check further on the supply conditions. When the main metering is done with a power and a reactive watthour meter it may be possible to run the suspected motor alone and check the power factor by counting the revolutions of the disks on the two meters simultaneously. Low voltage may also cause an apparent increase in current reading.

By using a graphic ammeter the load conditions may be determined over a period. An ordinary ammeter inserted in the circuit does not give a correct picture in most cases because the current varies and swings continuously and it is hard to keep the readings in mind. Besides, an ordinary ammeter has to be watched continuously while the graphic meter may be set and then the electrician can go about his other duties. A power survey undertaken with a graphic meter takes very little time and can be carried on without interfering with the regular electrical maintenance schedule. By keeping a typical set of charts for each motor, comparisons may be made at any time, and when some changes are to be made in the set up of the driven machinery it is possible to predict what changes, if any, will have to be made in the drive.

Fuel Research

At its meeting during A.S.T.M. Committee Week in Columbus, O., March 6 to 10, Committee D-5 on Coal and Coke received a report from the Subcommittee on Dustiness that it has reached agreement on the standardization of a testing procedure for determining the relative dustiness of either coal or coke. By these procedures it will be possible to evaluate the effectiveness of various treatments available for eliminating the formation of dust which is often objectionable when handling solid fuels. Application of various treatments to coal and coke for the reduction of dust has greatly increased the consumer's satisfaction with these fuels, especially for domestic use.

Another important project involves the development of a standard method for determining ignitibility of coal and coke. Following a recent meeting, agreement was reached on an essential point, namely, a statement or definition of this property as follows:

"The ignitibility of a fuel is that characteristic which determines the ease with which the fuel may be brought to a condition of self-supporting, active oxidation. The ignitibility is governed not only by the inherent chemical characteristics of the fuel that determine its rate of oxidation at various temperatures but also by the physical characteristics of the fuel and its surroundings that determine the rate at which it can be heated. Among these physical characteristics are (1) the size of the pieces of fuel, (2) the specific heat of the fuel, (3) the thermal conductivity of the pieces and the aggregate, (4) the rate at which the oxygen or air is brought into contact with the fuel, and (5) the rate of heat loss to the surroundings. Chemical and physical changes, such as melting and decomposition of bituminous coal, may occur as the fuel is heated."

An ignition temperature of a fuel cannot, therefore, be considered an independent characteristic, but such a temperature, at which the rate of oxidation attains some definite value under standardized conditions, may be a useful criterion of the performance of the fuel in combustion equipment.

It was announced that the group concerned with plasticity and swelling of coals for coke-making had distributed a series of different coals to various cooperating laboratories to be tested by different methods under consideration. All methods now in use are necessarily empirical in nature and require close standardization to be of value. A special section has been formed to study swelling of coals when fired on grates since this is a different problem from expansion during coking.

A special subgroup has examined installations of plain chromium and chromium-nickel steel used for architectural purposes in New York City, Philadelphia, and Atlantic City, to determine the conditions of the material after exposure to industrial and sea coast atmosphere. A report is being developed to give the results of inspection and to include chemical composition of the materials, method of fabrication, etc. This information will be included in the 1939 Report of Committee A-10.

Vegetable Oil Manufacturer Modernizes Switchgear

IN MEETING the requirements of increased business, the Archer Daniels Midland Company, large manufacturer of vegetable oils, has provided greater assurance of continuous service through a program of switchgear modernization at its Edgewater, N. J., plant, according to William A. Foley, plant engineer. The new switchgear installation, recently completed, includes nineteen General Electric metal-enclosed cubicle units. In addition six large power transformers and four Pyranol-filled capacitor racks were installed to increase capacity and maintain power factor.

In the plant's manufacturing processes, electric service is required for the operation of conveyors, presses, kettles, and in many other allied applications, on a 24-hour-a-day basis. The total connected load of the plant is 6308 hp., of which 2267 hp. was connected to a revamped switchboard that had been originally installed in 1912 to distribute 350 kw. at 440 v. The board's panels were of the conventional live-front vertical type, of slate, with instruments, knife switches, and fuses mounted on the front, exposing live parts. Mounted on the rear of this old board, which served twelve plant departments, were oil circuit breakers, buses, connections, and instrument transformers. These also were exposed to accidental contact, and there was no provision for isolating the oil circuit breakers from the bus. This was not recognized as poor practice 25 yr. ago.

However, the plant had outgrown the normal capacity and interrupting ratings of the oil circuit breakers and it was necessary that experienced electricians be available at all times to avoid complications. There was a constant threat to continuous plant operation, fire-insurance rates were high, and so were maintenance costs. As a result it was decided to replace the old switchboard with up-to-date switching equipment. Incidental to the installation, transformer capacity was increased by 50 per cent, a margin safeguarding the current production rate and providing for future expansion.

The new switchboard is designed so that the incoming and feeder equipments are each enclosed in a separate unit. This provides flexibility by localizing departmental shutdowns, as far as the control equipment is concerned, and also provides safety to men working on the equipment. Shipped-assembled units of the cubicle type manufactured by the General Electric Company were used. The high-tension board consists of two 2400 v. incoming line cubicles and the low-voltage end has seventeen cubicles, two of which are blank panels providing for future circuit and metering.

No live parts are exposed, and, in each cubicle, group-operated disconnecting switches are provided between the oil circuit breakers and the bus bar. These disconnecting switches are mechanically interlocked with the oil circuit breakers and the hinged doors, so that access to the inside of each cubicle can be gained only when the disconnecting switches are open, and so that the disconnecting switches can be opened only after the breakers have been opened.

Since the new switching equipment was installed, according to Mr. Foley, plant officials, electricians and workmen are conscious of greater assurance that the plant will continue to operate uninterrupted on its 24-hr.-a-day basis. There has been a substantial reduction in fire insurance rates and, in addition, an increase in safety to workmen. Figures on maintenance costs are not yet available, but a substantial reduction is expected.

The complete changeover was accomplished in 32 hr., with all connections permanent and the plant back on its operating schedule, and the work was done entirely by the foreman, three electricians, and three helpers of the regular plant electrical staff. To install equivalent switching equipment, not shipped assembled from the factory, would have required from two to three weeks.

Midwest Power Conference

Present Status and Recent Progress in Technology of Power Industry Portrayed by Practicing Engineers at Conference in Chicago

AT THE Palmer House in Chicago on April 5 to 7 the Midwest Power Conference organization clearly demonstrated that the present arrangement under the sponsorship of important engineering educational institutions is accomplishing its desired purpose of a helpful exchange of ideas and data among educators, professional and industrial engineers. With over 500 individuals in attendance at the meetings and some 20 technical papers delivered, there was an evident desire on the part of the audiences to become as thoroughly posted as possible on modern practice in the field as the time would allow. Small power plants, central stations, metallography, air pollution, Diesel power, rural electrification and even the power industry's part in national defense were discussed at the Conference with an underlying endeavor to portray present practice and trends in the power field.

In the field of research L. W. Wallace stated that the physicists, chemists, metallurgists, ceramists and engineers experienced in industry, through the mediums of creative and applied research, couple their findings with the theoretical deductions of the searcher for fundamental knowledge, and give to the masses tangible, everyday working tools. He cited the electric eye, electric timers, color sorters, dimensional detectors, calculators, minute electric bulbs and other recently developed devices as direct results of research and development. Of particular importance are the automatic power plant control systems now coming into common use in nearly all operations from fuel unloading and ash handling to the final distribution of electric energy. Research is also contributing to longer life of equipment and the development of metals best suited to working conditions.

Progress in Power Plant Design

It was Alex D. Bailey's expressed opinion that the effort to produce a unit of power more economically is as strong today as it has ever been in the history of power production, possibly it is stronger. Even during the depression active research has been carried on which has resulted in developments in chemistry and metallurgy that are now playing an important part in station design, construction and operation. These developments have permitted engineers to use pressures and temperatures formerly prohibitive, even the power medium in general use may change. Welded pipe joints have become standard. Boiler heating surface proper is now reduced to 5 to 6 per cent of total with absorbtion in like proportion, while other parts of the boiler have been growing in importance, the water wall, for instance, with 5 to 6 per cent of the heating surface absorbs about 50 per cent of the heat delivered to the boiler.

Technical developments made in large plants are extending into smaller plants, was an opinion expressed by Gustaf A. Gaffert, the extent of their use being governed by economic considerations. At present, it would seem, that 450 lb. 750 deg. F. for steam conditions are basic in the design of small utility, municipal and institutional plants, any departure from those conditions must be studied carefully from an economic standpoint.

That power cables have undergone distinct changes in recent years was brought out by Herman Halperin who described in detail the construction and specific uses of cables known to the trade as: rubber, varnished cambric, impregnated paper, oil filled, high-gas pressure, and low-gas pressure.

In considering the fundamentals of generator station design, G. G. Post made the statement that "To strive for uninterrupted electric and steam services has, in this day, come to be expected. To accomplish this, spare capacity must be provided. Attention to detail is paramount, especially in the large units, where an outage would cause the loss of a large amount of capacity. High reliability tends toward low cost, and neither would be obtainable without intelligent applications of past experiences."

Among the things Mr. Post considered essential in designing for reliability of service is, first of all, an operating-designing organization, the two duties being linked closely together so that advantages can be taken of the experiences of both groups. He then considered in detail water supply, oil lines, piping, electric overload protection, grouping of controls and instruments, alarms and indicator lights, and spoke of the vestibule for coal cars which not only thaws out frozen coal but prevents cold air drafts and the strains they cause on piping and structure. Changes should be adopted if they show economy, such, for example, as increased steam pressure, installation of air heaters and superheat control. In operation, the highest economy can be secured by using the newest and most efficient equipment to carry the base load on the plant.

The term creep, as used by engineers and applied to metals, was defined by J. J. Kanter as a continuing change in the deformation or deflection of a stressed member. This quality of steel has become of increasing importance as steam pressures and temperatures used in industry have increased, and it was to the progress made in research laboratories to determine the effects of creep that Mr. Kanter's paper was devoted. His discussion included a statement as to the value of creep

The National Coal Association and local organizations in the Bituminous coal industry, as well as individual coal operators, have opposed the expenditures of millions and even billions for power programs which, if continued, will eventually create a most tragic situation in the coal mining fields. The electric utilities have participated in this fight to a certain extent but we feel they should have done more because the generators and dispensers of power have an economic stake in the Government's hydro-program that is just as great, if not greater, than the Bituminous coal industry.—Marc G. Bluth.

studies to industries and a history of research work done, character of creep, creep stress, test methods and apparatus, reliability of creep data, its source and utilization, and allowable working stresses based on creep data.

Considering the entire field of power in which the Diesel engine has had a distinct part, L. H. Morrison addressed one session on the social significance of the development of Diesel power pointing to many changes in industry, transportation and agriculture that have come about through the application of the Diesel principle of burning oil in engines.

Citing problems overcome during the past 10 yr. in the application of Diesel engines to tractors, C. G. A. Rosen stated that the primary reasons for the existence of the Diesel engine is its native ability to afford high economy in the consumption of relatively cheap fuels. Low fuel costs plus economical maintenance must total less money than competitive units to justify the Diesel tractor's economical survival. Some outstanding accomplishments have been made in Diesel fuels, specific lubricants, improved metallurgy, and precision workmanship. A Diesel tractor will consume in dollars and cents the equivalent to the original cost of the engine in from 1½ to 2 yr. depending upon the conditions of service. The first successful Diesel tractor was put into operation in 1931, in 1937 the horsepower of Diesel tractors put into service amounted to 1,100,000.

Rural Electrification

Reporting on a survey of rural service of Wisconsin utilities, B. E. Miller stated that an allowance of $400 per customer under construction standards of 10 yr. ago permitted extensions where three customers per mile could be obtained. Today's standards, using copperclad wire and yellow pine poles, will permit extensions where an average of 2½ customers, or less, per mile can be obtained. The number of customers served at rural rates by private utilities in Wisconsin increased from 7429 in 1923 to 34,800 in 1930 and an estimated 66,700 in 1938. Under average conditions and prevailing prices of material and labor a mile of line with two customers per mile will cost $816.59, up to $1007.52 for a line serving 3.3 customers per mile.

It was stated by V. M. Murray that the REA in December '38 allotted $8,544,800 for the construction of 7676 mi. of line to serve 24,156 customers and $1,595,000 for the generating plants and transmission lines in Wisconsin. In the construction of rural lines a saving of $49.80 per mile was effected by using the 4-wire grounded Y system instead of the 3-wire delta and a further saving of $61.40 by the use of high-strength conductors. In regard to rural electric rates, he stated that wholesale rates averaged about 1.5 cent per kw-hr., retail rates start with a minimum for the first 40 kw-hr. ranging from $2.50 to $4.00 per month with the majority at $3.50, the second 40 kw-hr. is from 4 to 6 cents, third 40 is 2 to 3 cents with all excess at 1.25 cent.

The elimination of objectionable impurities from flue gases discharged into the atmosphere has not been solved to a satisfactory degree. "The problem of smoke," said R. V. Kleinschmidt, "has been minimized by intelligent handling of modern combustion equipment. There still remains to be eliminated solids in the form of cinders and fly ash, and certain acid gases of which the major one is SO_2." He classified dust collectors into two general types and described their principles of operation, then discussed a method that has been devised for the removal of sulfur gases as a supplementary service performed with a certain type of wet dust collector.

We have always been so accustomed to thinking in terms of a reasonable return on our investment that comparatively little technical analysis has been devoted to the problem of transmitting power beyond 300 miles. The philosophy of regarding trunk lines and connecting tie lines as a part of our equipment for national defense has indicated the need for exploration of this field. Schemes which hitherto were discarded for economic reasons must now be reconsidered, and a review of some of those which have been recently advocated for the transmission of power over long distances may help to clarify existing conditions.—M. W. Smith.

Continuing the discussion of air pollution, Loyd Stowe gave a history of smoke abatement ordinances in Chicago over the past 30-yr. period. The commendable work of the railroads, power utilities and steel plants was cited as an indication of the cooperation the city is receiving from industry in reducing air pollution. Residential fires are today the greatest offenders. The use of gas as heating fuel is helping the situation some and it was stated that an endeavor is being made to develop smokeless fuel from Illinois coal. Dust fall 15 yr. ago averaged 300 tons per sq. mi. per mo. in Chicago, it is about one-third that amount today.

"Successful functioning of a power plant, its cost of construction and operation and its reliability," said Geo. C. Daniels, "depend to a great extent upon the proper selection and installation of the auxiliary equipment. The kind of power plant auxiliaries and the method of driving them will be governed by the size and function of the plant and whether it is an isolated plant or part of an inter-connected system." He classified the auxiliaries into essential—those required for continual functioning of the plant—and non-essential —those not needed continuously. In an endeavor to achieve reliability, some designers have resorted to complicated designs that may in themselves be a source of unreliability due to a failure of some relatively minor link in the operation. Simplicity is a vital ingredient of reliability. For gas and oil fired plants the per cent of gross generated power required by the aux-

iliaries varies from 3.5 to 4.0 per cent, for stoker fired 4.0 to 5.0 per cent and for pulverized fuel plants 5.5 to 6.5 per cent.

In an endeavor to arouse interest in undertaking or enlarging a fact and cost finding system, with the assurance that if you do, you will profit greatly, Arthur L. Rice discussed the fundamentals of power plant statistics. Statistics are of no use, he said, unless the data are relevant, accurate, complete and are studied, analyzed, compared and deductions made. Then they reveal costs, trends, efficiencies, defects to guide in planning and correcting construction, equipment and operation. The three general purposes for which power plant statistics are kept were given as: (1) To determine changes and trends in the field. (2) To check plant operations. (3) To determine costs of producing power and heat.

Discussing railway motive power, H. P. Allstand stated that the "Pioneer", the first locomotive to be used by the C. & N. W. Ry. was built in Philadelphia in 1836, was brought to Chicago by boat and put into operation in 1848 as the first locomotive to operate west of the Great Lakes. Just 90 yr. later this company had nine streamlined steam locomotives in service. Comparing the "Pioneer" with the 1938 type he gave the following table:

	Pioneer	1938 Type
Wt. of Locomotive complete	24,000 lb.	772,000 lb.
Cylinder dimensions	11x18 in.	25x29 in.
Steam pressure	100 lb.	300 lb.
Driving wheels	No. 2; dia. 54 in.	No. 6; dia. 84 in.
Boiler, material	Iron	Nickel Alloy Steel
Fuel	Wood	Coal—Automatic Stoker
Tender capacity	1000 gal.	20,000 gal. water 25 t. coal
Maximum Speed	25 m p.h.	125 m.p.h.
Maximum hp.	200	3400
Thermal Efficiency	2.5%	7.5%
Tractive Power	3400 lb.	55,000 lb.

Developments in American pumps and hydraulic turbines during recent years were reviewed by R. V. Terry who stated that present procedure in design is to make use of experience and coefficients derived from tests on actual machines or models; to plot and study those coefficients against some characteristic, usually specific speed; and finally to accumulate curves of proportions and essential coefficients. It was reported that tests on pump models for the Colorado River Aqueduct have enabled designers to secure 3 per cent improvement in performance of the installed pumps. Studies are now in progress on pumps for the Grand Coulee irrigation project.

Hydraulic turbines also have undergone many radical changes in design during the past decade which have improved their efficiency and reliability. Over a period of 15 yr. the average annual rate of turbine manufacture has been about 1,000,000 hp., but at present there are under construction hydraulic turbines that total 2,250,000 hp., and the total installed capacity in the United States in 1938 was 18,000,000 hp.

At the two luncheons and the dinner the topics discussed were of a more general nature. "What Price Hydro Power?" the topic of an address by Marc G. Bluth was a dissertation from the viewpoint of the coal industry on the activities of the Federal Government in the field of hydraulic power generation. W. F. Sims spoke on the subject "Reliability of Power Supplies to Metropolitan Systems" and outlined the precautions taken by utilities to insure continuous and reliable power supply. At the dinner two addresses were given which had to do with the power industry's service to the country in national emergencies, M. W. Smith speaking on the subject "Power Transmission in a National Emergency" and William McClellan on the topic "Power for Preparedness".

Originally, long-distance transmission was adopted to promote the development of cheap water power, and the most economical sites were developed during a period when steam stations required from three to five pounds of coal per kw-hr. Today, the coal consumption on some of the new stations has been reduced to less than one pound per kw-hr., with the result that if strict economics are considered, in the majority of cases load growth is best taken care of by steam stations located near the load centers. This trend has continued, until today, taking the United States as a whole, the average transmission distance is less than twenty miles.—M. W. Smith.

Electron Tubes — Principles and Applications

(Continued from p. 335)

produced by the amplifier itself. This remarkable behavior is a consequence of the fact that when the feedback is large the voltage actually applied to the amplifier input terminals represents a small difference between relatively large signal and feedback voltages. A moderate change in the amplification A therefore produces a large change in the difference between signal and feedback voltages, thereby altering the actual input voltage in a manner that tends to correct for the change in amplification.

The importance of negative feedback can scarcely be over emphasized. Before feedback was developed the output of all electron tube devices, more or less independent of circuit arrangement, was greatly affected by the plate and filament supply voltages. In some cases a 10 per cent change in plate voltage would cause a 20 per cent change in output even if the input remained constant. With the development of feedback almost unlimited improvement in stability and regulation became possible. With many of the new feedback circuits, variations of output with changes of plate or filament voltage are reduced to 10 or 20 per cent of their former values, using simple and practical arrangements. With special precautions much greater improvement is possible. Indeed, a number of manufacturers have recently brought out electron tube measuring instruments that are accurate within 1 or 2 per cent when supplied from the ordinary 110 v., 60 cycle system without regulating devices of any kind. A few simple feedback circuits are shown in Fig. 7 but the principle is applicable to almost any type of amplifier circuit.

Readers' Conference

These pages are open to readers for the presentation or discussion of any timely power plant topic. The Editors invite your participation.

Belt Slip

MR. NEER'S observations on preventable losses in power transmission equipment, leading to the conclusion that the cost of such losses runs to astronomical figures, should be given careful consideration by owners as well as engineers.

Before deciding, however, to make the expenditures that would be necessary to so improve all the equipment in the country, as to make the savings he has indicated, it should be inquired whether Mr. Neer has not gone amiss on some of his assumptions.

Belt slip is not a trivial loss, and if we could, as he states, eliminate it entirely, the saving would be tremendous. More detail as to the means proposed for this total elimination of belt slip would be intensely interesting. One sure way of course would be to replace all belt drives with some other forms of drive where there is no slip, like chain drive, gears or individual motor drive for each machine. Unfortunately each of these systems also has its disadvantages either in first cost, lack of convenience in arrangement, noise or a still greater power loss than that due to belt slip.

It is possible, too, to reduce belt slip to a very low figure, appreciably less than the 2 per cent mentioned by Mr. Neer, by ample proportions of the pulleys and belts, so that the stress in the belt is a minimum. Here again we are faced with a tremendous first cost making the increase in charges for interest, amortization, etc., more than offset the saving effected by reducing the belt slip.

Finally, in considering belt drives we must not lose sight of the fact that even in the best designed belts we can not entirely avoid some loss. Even though we make our drive generous enough to avoid slip we shall still have creep or stretch. This loss is due to the fact that in order to transmit power there must be a difference in tension on the two sides of a belt giving rise to the terms tight side and slack side. As a section of the belt on the slack side approaches a pulley it is somewhat shorter than when it leaves the pulley on the tight side. In going around the pulley the section of belt has been slightly lengthened, meaning that the belt has traveled slightly further than the pulley and since it is the driven pulley on which this action takes place, it follows that there is a loss between the belt and the pulley. This loss, termed "creep," is placed at less than 1 per cent in well designed drives, but it cannot be entirely eliminated.

It is inherent in a belt drive, just as we have friction in bearings, electrical losses in transmission lines, power losses in converting mechanical energy into electrical for convenience in transmission, and to a greater extent, in converting the energy of steam into mechanical energy in a steam engine or turbine.

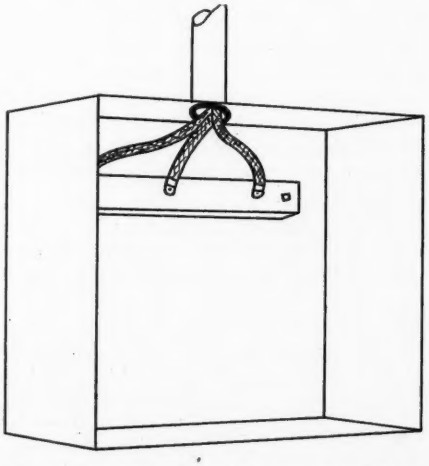
All of which simply leads to the conclusion that while designers of power equipment, whether for generation, transmission or utilization should always keep in mind the highest possible efficiency of such equipment there remains a point beyond which the cost of such efficiency becomes greater than the saving that may result in the operation of the equipment.

Pottstown, Pa. T. HOLTZ.

False Studs Facilitate Wiring Work

WHEN RUNNING heavy conductors into cabinets, switch-boxes or magnetic contactors, the work of shaping and making up the leads to the lugs and clamp studs will be greatly lessened if the entire switch assemblage be removed from the steel box.

Bolt a piece of wood into the box, using the bolts originally holding the switch-gear, in such a position that three false terminal studs may be set up on the wood, exactly as they were placed on the original equipment.



Wood strip used as templet in mounting switch

Make up the conductors to these false studs. With the entire box interior to work in, and with no sharp metal parts to protrude and bark the knuckles it will be found that the conductors may be bent, cut and soldered into place quite easily.

When the conductors are made up, remove them from the false studs, remove the wood backing and replace the assemblage of the switch, finally making the shaped wire ends up to the actual conductor studs.

West Warwick, R. I. JAMES P. MARSHALL.

An Emergency Standby

DURING the summer months the power plant in our factory was shut down each week end, and started up early Monday morning. This gave the maintenance crew a chance to do repair work, as the nature of the product was a continuous operation.

The power plant consisted of a 600-kw. steam engine and a 1000-kw. steam turbine, all auxiliary equipment for the turbine was electric. The first step was to start the 600-kw. engine, which had a separate steam turbine driven exciter used for starting only. The exciting current was derived, from two 120-v. d.c. motor generator sets, one set was switched on; when full voltage was cut in on the bus bars, the steam turbine driven exciter used for starting only was then shut off.

One Monday morning the plant electrician received a call, that the steam driven exciter would not generate current. After a complete check up the trouble was found in the armature. Now the question was what to do, with plant schedule already delayed one hour, it meant a serious delay in production. A special hook up with the power company would take at least 3 hr., and other expense.

A suggestion was made to connect two cables from the batteries of a 48-v. electric truck, used for production in the factory. One hundred fifty feet of cable was used from the truck to the power house. A man then held the end of each cable on the brush holder of the slip rings. The voltage on the engine alternator came up to 220, only half of the required 440 v. The voltage being low, the magnetic switch was held in with a stick, to start one of the motor generator sets. There was enough power to start the exciter set which came up to 120 v., d.c. This was cut in on the exciting bus and the cable pulled off the alternator slip rings. The plant was then started in full, only 90 min. off schedule.

This method was used several times in starting until a new exciter was installed. The new exciter was directly connected to the engine alternator with a V belt drive.

Rockford, Ill. NELS W. OMAN.

CHIMNEY Gas Washing to remove sulphur by a process devised for Fulham (London, Eng.) Power Station, is stated by Dr. R. Lessing to have shown reduction by government tests to an average of 0.0046 grains acidity per cubic foot of dry gas. The process was described in a paper before the London Section of Society of Chemical Industry.

Sub-station Architecture

WHERE IT IS NECESSARY to construct Supervisory Control sub-stations operated by remote control from other stations of the system, the Hydro Electric Power System of Ontario, Canada, design the building fronts

Two views of attractive substation located in residential district

in residential areas to harmonize with adjoining residences. In this way the value of property is not jeopardized by a building that is not in harmony with the district. In the photographs the front and rear views of one of these stations is shown that serves one of the residential districts in the city of Hamilton, Canada.

Hamilton, Ont. JOHN E. MASON.

Reconditioned Lubricating Oil

REGARDING the letter by R. G. Dickens, page 217, of the March issue of POWER PLANT ENGINEERING, I have carefully reread my original article under the above title, which appeared in the February issue, page 147. I fear Mr. Dickens was somewhat careless in reading my article as I did not say nor did I intend to imply that lubricating oil cannot be successfully reclaimed. I did say this, "As a result, to make such lubricants safe and satisfactory, the correct purifying process is so expensive that competition with the new oils is impossible."

Lubricating oil can be reclaimed, and it can be

successfully reclaimed under proper conditions. But when the cost of new lubricating oil becomes less than the cost of reclaimed oil, as discussed in my article in the February issue, it is logical that buyers of oil will prefer the new oil.

The concern referred to in my article that went out of business, for reasons as explained, was at one time doing a thriving business. For example, the City of New York was a customer, and the City of New York has its own chemical testing laboratories. The reconditioned oil was carefully tested in the laboratories and at times was reported as being actually better than new oil—all of which confirms some of the statements made by Mr. Dickens. But when the price of new lubricating oil dropped considerably below the price that the City of New York was obliged to pay for reconditioned oil, they naturally ceased reconditioning their oil and began buying new oil. Other important customers did the same thing. Whereupon, after hoping for many months that the powers that be would raise the price of new lubricating oil, the reconditioning concern was obliged to give up, and as stated in my article, they sold their entire equipment for junk.

Newark, N. J. W. F. SCHAPHORST.

Paint Cost

PROMPTED by the increasing number of requests for comparative cost data, particularly on aluminum paint, the American Asphalt Paint Co. has established an impartial, unbiased method of measuring all the factors that enter into the eventual and real cost of painting a given surface, its length of service and performance efficiency.

Believing that the only true yardstick with which to measure paint performance and paint costs is its cost per square foot per year of service, the company has attempted to reduce the question to a mathematical equation, the results of which enable a buyer of paint to establish an actual, as well as a scientifically correct basis of painting costs and to arrive at the AFC (annual foot cost) rating of a specific brand of paint.

To determine the annual-foot-cost of paint, divide the cost per gallon by the number of square feet covered per gallon—then divide the hourly labor cost by the number of square feet painted per hour on a given job. Add these two results and divide by the number of years of service or life of the paint. Carried out, this procedure will provide the AFC rating —and the true cost of the paint.

$$\frac{\text{Cost per gallon}}{\text{Sq. ft. covered per gal.}} + \frac{\text{Hourly labor rate}}{\text{Sq. ft. painted per hr.}} \times \text{Life of paint in years} = \text{AFC}$$

The length of life of paint, of course, varies due to the intensity of the conditions under which a product has to stand up. For example, the Florida climate is considered the toughest there is on paint and nearly all large paint manufacturers maintain paint testing stations down there because they know if their products stand up exposed to that heat and humidity for, shall we say, 2 yr., they will undoubtedly last double that length of time in most other sections of the country.

From years of experience with actual paint jobs and with very carefully checked scientific tests such as those held in Florida and other points, manufacturers can very accurately determine average figures for the length of the life of any paint film which they market.

There are many variables on every paint job, including the type of surface, weather conditions, and the ability of the painter so that figures are not strictly comparative and would not necessarily be a good basis for judgment on the cost of any specific job.

However, from experimenting with the actual cost of paint and paint application on several dozen jobs in central Illinois, we find the following figures to be average for three of this company's typical products:

A Factory, Bridge and Barn Paint (for exteriors)

Cost per gal.	$1.80
Sq. ft. per gal.	506
Hourly labor cost	$1.00
Sq. ft. painted per hr.	102
Years of service	3.7
AFC rating (from formula)	0.0036

Asphalt Aluminum Paint (for exteriors)

Cost per gal.	$4.75
Sq. ft. per gal.	880
Hourly labor cost	$1.00
Sq. ft. painted per hr.	192
Years of service	6.2
AFC rating (from formula)	0.0017

A Casein Paste Paint (for interiors)

Cost per gal.	$2.20
Sq. ft. per gal.	902
Hourly labor cost	$1.00
Sq. ft. painted per hr.	282
Years of service	2.9
AFC rating (from formula)	0.00205

All of the figures were taken from jobs where the surface conditions were very good, and each was applied over a previously painted surface. It is interesting to note that the $4.75 per gallon paint in the long run actually costs less than half as much as the paint selling at $1.80 per gallon and that incidentally is considered one of the finest barn paints on the market.

J. STILLER.

Chicago, Ill. American Asphalt Paint Co.

Removing Broken Studs

I read with interest the method of removal of broken studs, and my method, although very similar, may be of interest. It uses an oxy-acetylene welding torch and a bronze welding rod. When a stud is broken the top is first cleaned to permit good welding. Then all around the sides of the stud hole and the top of the hole are painted with a heat resisting paint. This is applied with a very small paint brush or piece of wood and will prevent the weld metal adhering where not desired. As soon as the paint dries sticky a nut should be placed centrally over the hole, the central hole of which is slightly smaller than the tapped hole. The paint is then allowed to dry and this will hold the nut in place. Then take an oxy-acetylene torch and a bronze welding rod and using the hole in the nut as a target proceed to direct weld metal into the hole until the stud and the nut are welded together. On the weld metal cooling, the stud can be removed by turning the nut with a spanner.

Care must of course have been taken with the painting to prevent the weld metal welding to the main casting or forging.

London, England. W. E. WARNER.

Convenient Customer Record

IN DISTRICT heating systems steam consumption is usually measured by recording the condensate through condensate meters. It is a comparatively simple job to divert condensate by tapping return lines in some manner or other.

To care for these conditions, as well as to help handle legitimate service inquiries, we have worked out the enclosed loose leaf form to give a complete customer history that enables comparisons to be made for the same month in different years.

The degree-days is computed for each billing period and the readings vary approximately in proportion to this figure. To get a series of readings that are more nearly proportional to degree-days, subtract the August reading (practically 100 per cent hot water heating) from the rest of the readings. Another factor that we have found to destroy the degree-day proportionality is the wind velocity. In fact we usually find that our largest station steam send-out occurs on a day with a moderately low temperature (say 25 deg. below zero); this, in spite of the fact that we usually have a few days that average about 36 deg. below zero.

Over a period of years this system of recording heat readings has proved very satisfactory here.

ARTHUR L. BENNETT.

Hibbing, Minn.

Steam Heat Service Record

Water, Light, Power and Building Commission
Hibbing, Minnesota

Owner George P. Murphy No. 2811 St. or Ave. 3rd Avenue W.

Lot 31 &32 Block 3 Addition Parkview

Type of Building Residence Area of Main Floor 784

Type of Construction Frame-Stucco Number of Stories 2

Basement Yes Exposure 4 sides Condition good

Size of Service 3" Size Branch Service 1½" Size of Return none Size Branch Return 3/4"

Length of Service: Main Service 70' Branch 20' Covering: Mains yes Risers yes

Size of Meter Cad. "A" Press. Red. Valve none Automatic Temp. Control none

Converter Size Adsco #8 Converter Rating 1100 squ. ft. Size H. W. Tank 40 Gallons

Type of Heating System: Steam Hot Water yes Central Blower Unit Heater

No. of Steam Radiators 1 (in garage) EDR 60

No. of H. W. Radiators 10 Sq. Ft. EDR 390

Rating of Central Blower BTU/Hr. EDR

Rating of Unit Heaters BTU/Hr. EDR

Rating of Tankless HW Heater 30 GPH EDR 140

or Rating of Tank Heater GPH EDR

Total EDR 590

STEAM CONSUMPTION
M Pounds

Meter No. 658

Month	1936	1937	1938	1939	1940	1941	1942	1943	1944
January	37	38	35	33					
February	31	30	32	29					
March	16	15	17						
April	8	7	6						
May	6	5	5						
June	4	3	4						
July	3	4	3						
August	2	3	2						
September	7	8	6						
October	13	12	14						
November	29	30	28						
December	38	37	34						

Name of Customer: George P. Murphy Account No. 3241

Stainless Steel Stopped Corrosion Trouble

OPERATING three h.r.t. boilers which are constantly run at quite an overload, and having no spare unit, it is necessary that these boilers stay on the line. I was having no end of trouble with brass feedwater line bushings in the front head and fusible plugs in rear head failing due to the chemical action of boiler water which was about 90 per cent made up from zeolite water softener. The effect was the decomposition of the brass bushing and plugs to a honeycomb appearance and no warning was given as to when they were going to fail. In fact, I have had the best fusible plugs that I could buy fail in less than a week's time.

I tried different cures such as placing zinc in each boiler at each washout, grounding boilers electrically, placing additional brass in boiler but to no avail. So I hit upon the idea of making in the shop fusible plugs and feedwater line bushings out of 18-8 stainless steel and after 18 months of constant operation under the same conditions as before they still look as good as when they were placed in service.

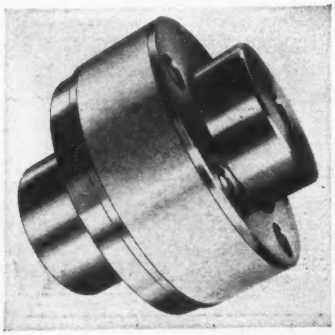
Seymour, Ind. WM. HEIWIG.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

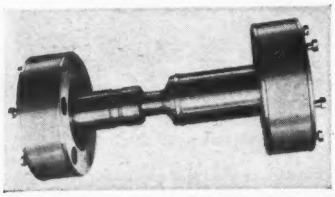
Radial Coupling and Drive Shaft

MANUFACTURED by Morse Chain Co., Ithaca, N. Y., the Morflex radial coupling is made in various sizes with capacity ratings of from 2 to 37 hp. at 100 r.p.m. Specially shaped rubber bushings are used which provide an effective flexing medium for withstanding shock loads and resisting vibration. These rubber blocks are assembled radially, equally spaced, on



the steel pins of the yoke or hub member. A two-piece metal housing encases the rubber blocks and also provides for attaching the companion flange to the unit. The entire coupling is machined to insure perfect balance. Since there is no metal on metal movement the coupling is fully insulated against noise and electricity and requires no lubrication.

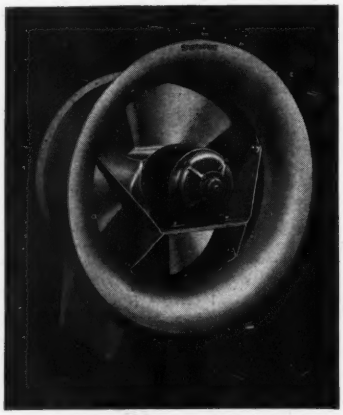
Made in two types in various sizes with capacity ratings of from 2 to 37 hp. per 100 r.p.m., the Morflex radial coupling drive shaft combines the features of the standard Morflex radial coupling in a high grade slip joint drive shaft for use as a remote drive, or



where added flexibility may be necessary. The slip joint is full spline construction, grease tight, and slides freely under load. Shaft members are accurately machined from high grade steel forgings, piloted into coupling hub members and firmly welded. The entire shaft assembly is carefully balanced for smooth operation. The unit is specially adapted for use on dynamometer drives and other installations in which endwise shaft float may be encountered.

Pressure Fan

ADAPTED for almost any industrial application where the moving of large volumes of air against resistance, or where space requirements call for a rugged yet highly compact unit, the Sturtevant Axiflo Pressure Fan made by B. F. Sturtevant Co., Hyde Park, Mass., is available in 11 sizes ranging from 18 to 60 in. diameter with capacities up to 75,000 cu. ft. per min. Blades are so pitched that regardless of wind direction or velocity or fan location, there is no appreciable effect on air delivery.



The Axiflo pressure fan has a mechanical efficiency of 79 per cent and the ability to overcome system resistance up to 1½ in. water gage. It possesses the economical operation advantages of the axial flow type of fan combined with the performance of the centrifugal fan. Unlike the ordinary propeller fan, the Axiflo pressure fan is ruggedly constructed. Casing is heavily built and fitted with streamline inlet. Wheel is of solid and integrally cast heat-treated aluminum alloy which is non corrosive under the action of most acid content chemical fumes. The Axiflo pressure fan is available either for direct connected motor drive (as illustrated) or for belt drive, and arranged for wall, floor, platform or ceiling installation.

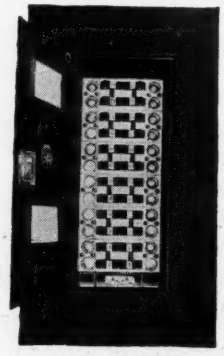
New Switch and Panelboard

BULL DOG ELECTRIC PRODUCTS Co., 7610 Jos. Campau St., Detroit, Mich., announces a new safety switch and a line of lighting panelboards incorporating a Rocker principle of front operation.

The Rocker Type Safety Switch, a 30-amp. front-operated enclosed switch, has a curved molded handle which is rocked by thumb action to "On" or "Off" position. Handle and switch mechanism are all one piece, operating on frictionless knife-edge bearings. Provision is made on the handle for marking circuit legend.

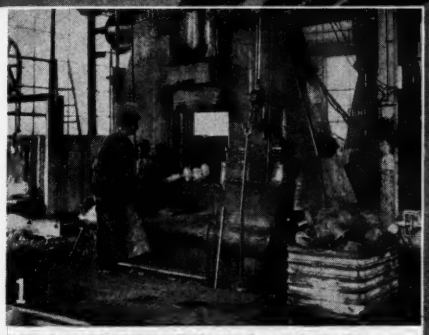
The switch is of modern streamlined design. Positive action full-floating contacts, screw type wiring terminals, ten well-placed knockouts, silver-surfaced current-carrying parts are other features.

Rocker Type Panelboards are a companion development to the Rocker Type Switch. Rocker handles make "On" and



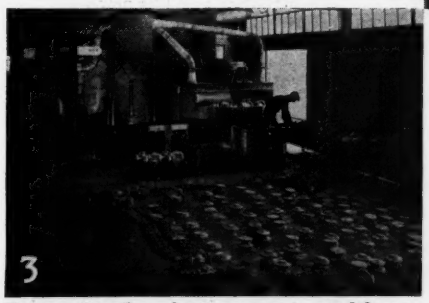
"Off" operation safe, simple, and sure. Circuit name or number can be written on a card inserted in the handles. Panel unit is of porcelain for maximum dielectric strength and resistance to heat. Other features: wiping action assuring clean contact surfaces, quick-make and quick-break switch action, exposed screw type wiring terminals, silver-surfaced current-carrying parts, molded "On" and "Off" markings, modern appearance. Available in circuits from 4 to 40, in multiples of 4.

FORGINGS BREED CONFIDENCE

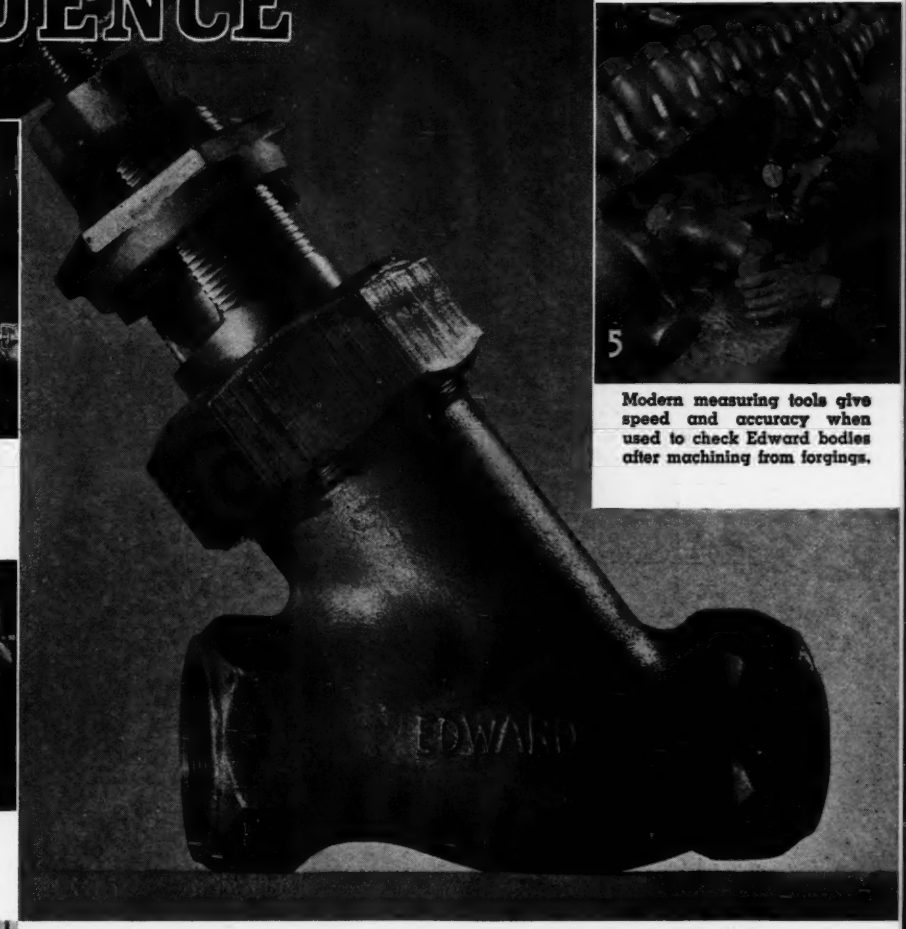


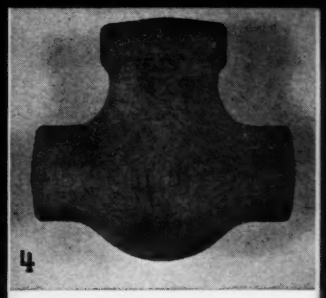
Pounding choice rolled steel stock under a heavy drop hammer increases its density until voids just can't exist. That's why users naturally have faith in valve body forgings.

Forging at high heat develops growth of grain structure — which may be corrected by proper heat-treatment. Edward normalizing furnaces are fired with refinery gas.



From cooling floor, forgings pass to revolving table where steel particles slung at high velocity remove oxidized jacket from heat-treated forging, preparing it for machining.





Sinking a drop forging die is nice work. One test is resultant fibre flow, revealed upon halving the forging.

Modern measuring tools give speed and accuracy when used to check Edward bodies after machining from forgings.

FORGINGS breed confidence. So Edward uses them wherever they are better than castings* or rolled steel. But you can't take forgings for granted until the raw material has survived acceptance tests. And before that, it takes years of study of the problems peculiar to high pressure valves before "specs" can be written wisely. Even when the stock is released for manufacture, after running the Edward testing gauntlet, inspectors hover near to throw out suspicious parts.

* Edward prefers castings for bodies over 2 inch.

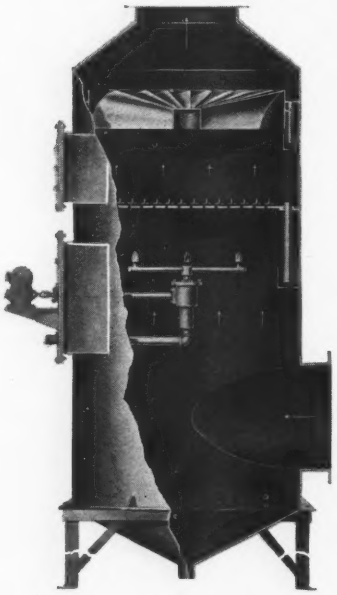
THE EDWARD VALVE & MANUFACTURING CO., INC.
EAST CHICAGO INDIANA

EDWARD VALVES

Stop · Check · Blow-off · Non-return · Feed Line · Relief · Bleeder Line · etc.

Scrubber

THE PEABODY ENGINEERING CORP., 580 Fifth Avenue, New York, N. Y., announces the development of a new model scrubber for the removal of fog, dust and other particles from gas and air. In the new model, known as the Peabody Triple Action Scrubber, gas enters tangentially near the base and is there relieved of coarse particles by cyclonic action. The gas passes upward through a zone of water or scrubbing liquid, supplied by slowly rotating sprays, operating at 10 to 15 lb. pressure where the dust particles mingle with water droplets. Continuing its travel, the gas encounters a plate with coarse perforations.

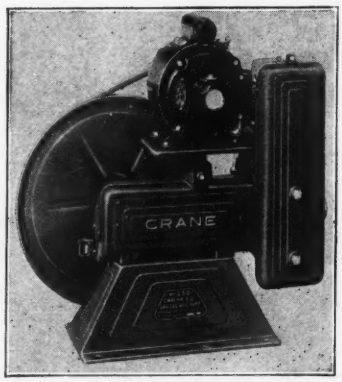


The mixture of gas, dust and droplets is shot through the plate perforations directly at square impingement baffles, constantly wet, arranged so that the stream coming through each plate perforation strikes its individual baffle at maximum velocity. The dust particles and water droplets, on impact with the wetted baffle merge with the water surrounding the baffle. At this point, the real and final cleaning takes place.

A liquid overflow pipe, located slightly above the level of the baffles, carries off the dust laden water, which leaves at the bottom of the scrubber shell. The gas or air, freed from impurities, is deflected around the baffles and continues upward toward the outlet of the shell. Eliminator vanes, located below the outlet, entrap any droplets of water carried upward in the gas stream, thus delivering dry gas.

Well Pumps

CRANE CO., 836 South Michigan Ave., Chicago, Ill., has introduced a new line of shallow well and deep well pumps. Referred to as the "Crane K Series" the shallow well pumps illustrated here are offered both in 250 and 375 gal. per hr. sizes and in both horizontal and vertical tank systems. They are designed for 40 lb. maximum pressure with 22-ft. suction lift, having a 1 in. suction and ¾ in.

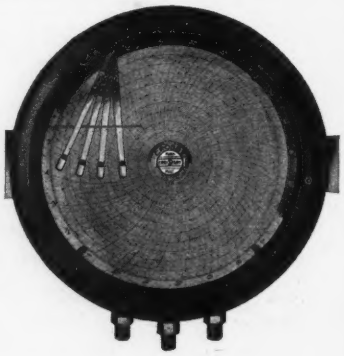


discharge. In conformity with the simplicity of its lines the manufacturers point also to the simplicity of the parts. Three basic sections, the power frame, water end and base are designed for perfect accessibility.

Designated the D-60, the deep well pump has a load balancing cylinder and silent herringbone gears which contribute to quiet, economical operation. It is available with different sizes of load balancing cylinders, giving flexibility to meet any operating condition efficiently.

Pressure Recorder

MADE by the Crosby Steam Gage & Valve Co., 30 Church St., New York, N. Y., in 10 and 12 in. sizes and in 1, 2, 3, or 4 pen types, the new pressure recorder is equipped with super-sensitive interchangeable Bourdon tubes of rugged proportions. Tubes, sockets, and tips may be easily removed as complete units and replaced for changes in pressure range. The micrometer calibration adjustment affords an accurate, rapid calibration by means of a large thumb screw which is locked in position to insure permanence of adjustment. All working parts in the movement are of stainless steel.



A new one-piece stainless steel reservoir pen has been developed for this instrument. This pen includes the capillary as an integral part and assures a fine, uniform line. Hod-type pens having equally fine writing characteristics are optional. Flexible stainless steel pen arms locked securely in position exert a light even pen pressure on the chart. They may be removed or replaced without disturbing the calibration. Chart changing is simplified by an automatic pen lifter which raises the pens clear of the chart when the door is opened.

The push-pull chart hub permits quick changing of chart without removing the hub. The hub is pulled forward, a new chart slipped into place, and the hub then snapped back into position.

To insure starting the chart at the exact time, a time set indicator and time markers on outer edge of the chart are provided. Either electric or spring-wound mechanical clocks are furnished; all clock movements are enclosed in dust proof cases.

The recorder cases are of cast aluminum and of a universal design which is adaptable to flush or wall mounting. The hinged door is fastened by an automatic cam lock which catches when the door is swung closed. The door is fitted with oil-resistant soft moulded gaskets to exclude moisture and dust.

Four Foot Fluorescent Lamp

A NEW LARGER FLUORESCENT Mazda lamp, available April 1st, has been announced by the Westinghouse Lamp Division, Westinghouse Electric & Mfg. Co., Bloomfield, N. J.

The significance of this new lamp lies in its extension of fluorescent lamp usage, because of the increased light output now obtainable from a single lamp. The new size will provide over 30 per cent more light. This reduces the number and cost of auxiliaries and accessories required for any given lighting job which reduction will have a marked effect upon the over-all installation costs.

The new size, being of the same diameter and having the same brightness as two of the four existing sizes, can be used with these sizes in designing lines of lamps placed end to end.

The complete list of sizes now is:

Length	Diameter	Watts
18 inches	1 inch	15
18 inches	1½ inch	15
24 inches	1½ inch	20
36 inches	1 inch	30
48 inches	1½ inch	40

The light output of the 48-in. lamp is 1400 lumens, compared with 1050 lumens for the 36-in. size. The new lamp is available in daylight and warm white.

Keeps Hot Process Softener Clean

FORMERLY it took just two weeks for the jet heater on a hot process type water softener in a western plant to completely choke up with scale. Because the temperature of the heater effluent was above the atmospheric boiling point, no satisfactory treatment was found until they used Nalco No. 18. Now the heater stays clean continuously. Scale has also been eliminated in the vent condenser.

Holds Water Stable at 330° F

HARDNESS of less than one grain per gallon in one plant recently was sufficient to form scale in a closed heater and drop the temperature from 330 deg. down to as low as 290 deg. F. in a week's time. Because such a loss is serious in many modern plants, something had to be done about it. It was: Nalco now keeps the heater clean continuously.

STABILIZED WATER is big news among plant operating men this year. Many have found that they can almost miraculously rid themselves of some of their most troublesome cleaning jobs: keeping scale out of boiler feedlines, pumps, heaters, economizers, engine cooling jackets, etc.

Stabilized Water, on the other hand, is not new to Nalco. For a number of years, we have been watching it, testing it, and producing it in customers' plants for temperatures as high as 400° F. We will be glad to give you complete information. *See your local Nalco representative, or write.* NATIONAL ALUMINATE CORPORATION, 6224 W. 66th Place, Chicago, Ill.

Stops Embarrassing Shut-Downs

FOUR years ago a prominent hotel put in a large air conditioning system. It worked fine except that each summer it had to be shut down, one or more times (amid complaints of guests) to remove scale from the cooling water system. Last year, they used Nalco treatment. Result: No shut-downs to remove scale.

Frees Engineer from Cleaning Job

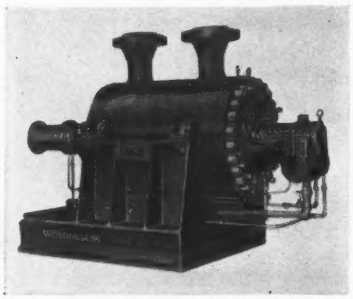
In a small plant in Minnesota, the storage type hot water heater has a direct connected coil running through the furnace. In a week's time, the heater and coil would scale up enough for the heater temperature to drop from 170 deg. down to 110 deg. F. and then it had to be cleaned. Nalco treatment now eliminates cleaning and permits continuous operation at maximum temperature.

ANY WATER NALCO SYSTEM ANY PRESSURE

Inquiries other than domestic, *except those from U. S. Possessions, Canada and Mexico*, should be addressed to ALFLOC LTD., Bush House, Aldwych, London, W. C. 2, Eng. Canadian inquiries should be sent to ALUMINATE CHEMICALS LTD., 372 Bay St., Toronto, Ont.

High-Pressure Centrifugal Pumps

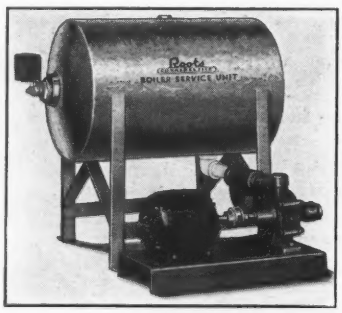
FOR APPLICATION to high pressure steam generating units, Worthington Pump and Machinery Corp., Harrison, N. J., announces its high-pressure, forged-steel-casing, centrifugal pumps. The pump casings are of forged steel, and all pressure joints are of the ring type, the joint universally accepted as proper construction for high pressure service. The con-



struction and design of the pump is such that it can be completely dismantled without disturbing the suction or discharge piping connections. Difficulties involved in the inspection, replacement or repair of any interior part are eliminated by the special construction of the rotor, which enables complete assembly outside of the pump barrel before insertion. All internal joints are so constructed that the hydraulic pressure acts to seat the joints rather than open them.

Self Priming Turbine Pump

BEING built for boilers up to 500 hp., at pressures up to 150 lb., self-priming turbine pumps, perfected by the Turbine Pump Div. of Roots-Connersville Blower Corp. of Connersville, Ind., during the past five years, have a bronze alloy impeller, chrome-plated shaft, bronze bear-



ings, cast-iron casing, and nitraloy seals. These seals rotate with the shaft, and eliminate the conventional stuffing boxes. Due to the inherent self-priming feature, these pumps will never vapor-bind.

The sale of such equipment is not limited to the heating season, as it is suited to the many applications, such as dairies, laundries, packing plants, breweries, canneries, greenhouses, cleaning plants, and many like services which require a constant steam supply.

The units are adapted to three types of service: condensate return for gravity systems, combination return and boiler make-up, and direct feed boiler supply. Duplex units can be supplied as required, and all units are furnished complete with all controls.

Ramfeed Stoker

MANUFACTURED by the Combustioners Div. of the Steel Products Engineering Co., Springfield, Ohio, the recently developed Type S Ramfeed Stoker is made in two grate lengths and four grate widths, giving six different grate areas, with coal burning capacities up to 2000 lb. per hr.

Charges of fuel are received from the hopper by a reciprocating ram and roller-bearing plate which operate at the bottom of the retort. The fuel is uniformly distributed over the entire grate surface. Different rates of coal delivery are obtained by changing the stroke of the plate in relation to that of the ram. This is done while the stoker is in operation by changing the position of a small weight arm on the crank shaft bearing. The plate is the only moving part of the stoker inside of the furnace.

The ram and plate are mechanically operated by a steel connecting rod and crank shaft through an all-steel spur-gear type speed transformer equipped with roller bearing and using heat-treated alloy steel gears operating in an oil bath. All bearings not flooded in oil are lubricated by Alemite-Zerk high pressure oilers.

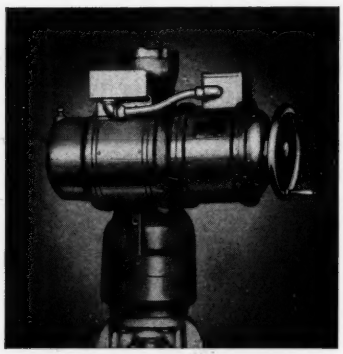
Pyrometer Controller

A VIBRATION-PROOF Celetray Indicating Potentiometer, Celetray Model V, has been developed by the C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y. Photoelectric detection of the position of a light-beam reflected from the mirror of a moving galvanometer provides an undiminished high sensitivity of the original Celetray indicating controller combined with practically instantaneous response. A new damped

photoelectric circuit has been developed which does not respond to abnormal disturbance of the light-beam. So far as vibration is concerned Celetray Model V acts somewhat as a filter, that is the action of vibration upon the galvanometer cannot effectively be transmitted through the instrument to the control device such as a magnetic contactor. This controller can be mounted rigidly in a vibrating panel along with the contactor or next to a drop hammer without regard for the possible effect of vibration. Vibration does not even cause the primary relay within the instrument to operate nor does it interfere with normal action of the controller.

Hydraulic Valve Actuator

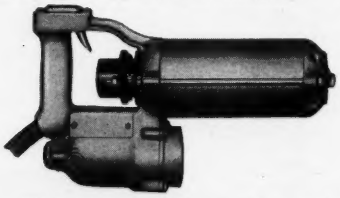
ANNOUNCEMENT is made by the manufacturer, W. F. and John Barnes Co. and their sales representative, Automatic Temperature Control Co., Inc., 34 East Logan St., Philadelphia, Pa., of the Barnes Multi-Power Hydraulic Actuator, a valveless, positive action, remote control for opening and closing all types of valves. Advantages are said to be high efficiency, longer valve life through the absence of severe operating shock, posi-



tive control and adjustability, adaptability for application to a wide range of speed, stroke and power application and a high degree of safety. The unit includes an adjustable pressure overload switch, non-inflammable fluid in the hydraulic system and an explosion-proof, weatherproof or water proof motor as desired. Emergency hand operation is provided capable of exerting pressures up to 1000 lb. per sq. in. Sizes available range from 4 to 36 in. valves with a gate lift ranging from 4½ to 38 in.

Electric Hammer

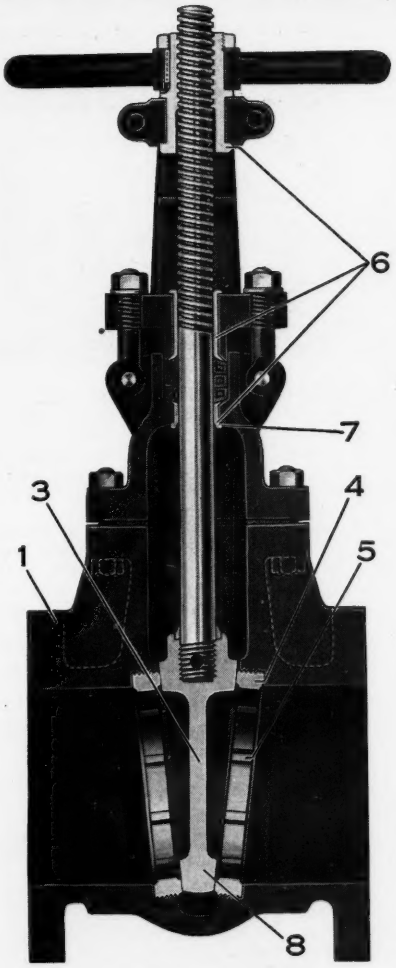
THE SYNTRON CO., 494 Lexington Avenue, Homer City, Pa., are just placing on the market, the most powerful electric hammer they have ever built for operation on the ordinary 110 volt A. C. lighting circuit—in their new No. 25 Hammer. Using star drills in this hammer, holes up to 2 in. in diameter can be drilled in the hardest concrete. Using stone points or cold chisels, it will cut holes through masonry floors and walls for risers, doors, windows, etc. It will drive up to ¼ in. cold rivets.



The hammer uses the regular patented construction of all Syntron Hammers, being made up of two magnets wound around a barrel in which is a free moving, heavy piston, that strikes directly on the shank of the tool being used. However, what makes possible such a powerful hammer, weighing only 25 lb., is the incorporation of a small, high speed blower motor in the handle, that keeps the magnet windings cool.

The hammer is 16 in. overall, 3½ in. in diameter and weighs 25 lbs. It is designed primarily for heavy construction drilling and cutting, and for large plant maintenance work.

When You Specify Iron Body Gate Valves Use this Check List



Iron Body Bronze Mounted

Standard { 125 lb. S.P. / 175 lb. W.O.G.

Heavy { 175 lb. S.P. / 350 lb. W.O.G.

Extra Heavy { 250 lb. S.P. / 500 lb. W.O.G.

Also regularly available in All-Iron patterns with renewable seat rings, for handling solutions which attack bronze but not iron.

LUNKENHEIMER

1. *Sound tough castings* that will safely withstand operating pressures and temperatures.	✓
2. *Uniform interchangeability of parts*, so that any replacement or repair part will be exactly the same size as that which is to be renewed.	✓
3. *Solid Disc* (not cored) that will not distort under temperature variations and pressure of the fluid handled.	✓
4. *Heavy renewable bronze seat rings* with special machine finish, and strong deep-cut threads that can be screwed tightly into the body without risk of springing the rings.	✓
5. *An ample number of substantial lugs* on seat rings to facilitate renewal.	✓
6. *Bronze bushings* between the bronze stem and iron parts of valve, to prevent corrodible contact and consequent scoring of stem and packing, which causes leaky stuffing boxes.	✓
7. *Back-seat bushing* in bonnet to provide a tight seat for repacking valve in wide open position.	✓
8. *Disc perfectly guided* so that it rides straight and true to its seat without touching seat rings until near the point of closure. To ensure this perfect guiding, the *guide ribs in the body* as well as the guide channels in the disc must be accurately machined.	✓

The sure way for you to obtain *all* these service-giving and money saving features is to specify Lunkenheimer Iron Body Gate Valves. Through their use you will effect substantial reductions in maintenance expense and valve costs.

ESTABLISHED 1862

THE LUNKENHEIMER CO.

"QUALITY"

CINCINNATI, OHIO, U.S.A.

NEW YORK CHICAGO
BOSTON PHILADELPHIA

EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

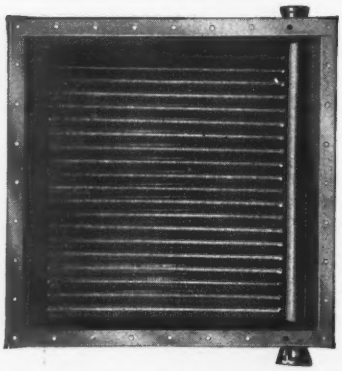
If you have no copy of List Price Schedule R1 giving new list prices of Lunkenheimer Products, ask your local Lunkenheimer distributor or write The Lunkenheimer Co., Cincinnati, Ohio

BOILER MOUNTINGS **LUNKENHEIMER VALVES** **LUBRICATING DEVICES**

6-79-44

Heating and Cooling Coil

LOW RESISTANCE to air flow is one of the outstanding advantages claimed for the Featherfin heating and cooling section now being offered by the L. J. Wing Mfg. Co., 154 W. 14th St., New York, N. Y. Either steam or hot water may be employed for heating, and cold water or refrigerant for cooling. The finned copper tubes comprising the heater section are made in hairpin shape to prevent damage from expansion and con-



traction strains. Tubes are individually replaceable in the case of accidental damage. They are secured to headers by a mechanical compression joint.

Made in two types, standard, in which steam is turned on or off by throttles to obtain temperature control and the Safe-Against-Freezing V.T. type. This latter type, is is pointed out, eliminates the possibility of damage due to freezing. This section is designed to permit close control of temperature of the air discharged, and is used for supplying fresh air or where inside air is recirculated. A series of built-in air by-passes controlled either manually or automatically provides the control of the temperature of the discharged air stream. It is stated that this unit produces better results and allows a more compact installation than standard sections with a "built-on-the job" by-pass.

Combustion Regulator

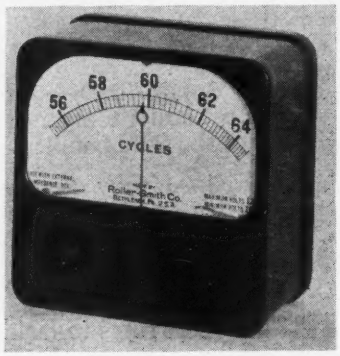
DESIGNED to hold the steam pressure in a gas fired boiler within close limits, and to control the air supply to the burner in conjunction with the gas resulting in high combustion efficiencies, the Type V080A Combustion Regulator made by Minneapolis Honeywell Regulator Co., Minneapolis, Minn., can be installed to fire automatically any radiant or blue flame burner of the atmospheric type.

Installation is extremely simple as the entire control is mounted on the gas valve bonnet at a single point. A ¼-in. steam supply and exhaust line and connection to the electric service complete the installation.

High pressure safety is one of the functions of the regulator, the convenient terminal panel, however, is arranged for each incorporation of additional safety devices such as a Lo-Water cut-off, a pilotstat or a protectoglo flame safeguard relay. Any interruption of the electrical safety circuit by one of the above devices will cause complete safety shutdown of the gas valve regardless of the demand on the regulator due to low steam pressure.

Frequency Meter

ROLLER-SMITH Co., Bethlehem, Pa., has recently placed on the market a new 4 in. square case frequency meter of the electro-magnetic type, with cases arranged for flush or surface mounting. The in-



struments have scale lengths of 3$\frac{5}{16}$ in. and are accurate to ¼ of 1 cycle, in the 60 cycle range. The normal range is from 55 to 65 cycles and the instruments are available for various voltages from 100 to 250. The price varies from 92 to 97 dollars. Dial illumination can be incorporated at a slight additional charge.

Duplex Welding Hose

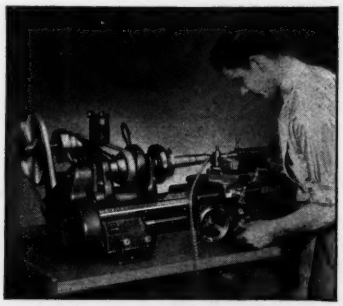
CONDOR DUPLEX WELDING HOSE, a development of The Manhattan Rubber Mfg. Division, Passaic, N. J., is a highly practical twin hose designed to make welding safer and more efficient than is possible with separate oxygen and acetylene lines.

In the construction of Condor Duplex, two hose lines are held together by a permanent web joint, integrally molded and having great strength and flexibility. The joint prevents tangling, kinking and snagging while the hose is in use. The ends are separated 18 in. for the torch end and 24 in. for the tank end for ease in making connections and in handling.

Condor Duplex Hose may be obtained in either one or two braid, or in heavy duty braid and spiral cord construction, depending upon the working pressures used. Features in the construction of the hose are strong inner tubes that are smooth and non-porous and tough, flexible covers that have a maximum resistance to abrasion and aging. Covers are furnished corrugated and colored red and green to distinguish the oxygen from the acetylene line.

Workshop Lathes

TWO NEW MODELS have been added to the well-known line of 9-in. Workshop Precision Lathes manufactured by the South Bend Lathe Works, South Bend, Ind. The new Workshop Model A is of the quick change gear type and has an automatic apron with friction clutch drive for operating the power cross feeds and power longitudinal feeds. The new Workshop Model B Lathe is of the standard change gear type and has also an automatic apron with friction clutch drive for operating the power cross

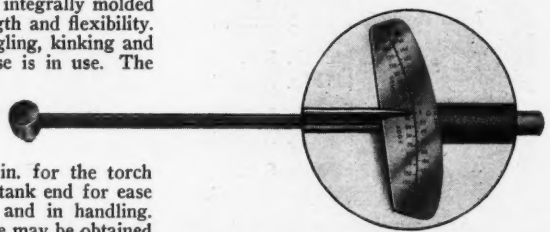


feeds and power longitudinal feeds. The present Workshop Model C Lathe has plain change gear equipment, power longitudinal carriage feeds through half-nut and lead screw, and hand-operated cross feeds. All three models are identical with the exception of the apron and the change gear equipment.

All three models of the Workshop Lathe are available in both bench type and floor type, with bed lengths in 3, 3½, 4, and 4½ ft. Several types of drives are offered, including horizontal motor drive for bench lathes, pedestal motor drive for floor type lathes, countershaft drive, V-belt horizontal motor drive and a 12-speed horizontal motor drive.

Indicating Wrench

BONNEY FORGE & TOOL WORKS, Allentown, Pa., announces the development of a low-priced torque-indicating wrench, known as the No. 56 Bonney Torque-Indicating Wrench, sturdily constructed with heavy, ground, spring steel shaft with pointer which remains rigid. The Bonney torque-indicating wrench is permanently adjusted, light in weight and of rugged constructoin, with no moving



parts to get out of order. It has full, chrome plated finish, buffed to a high, permanent luster and weighs only 3 lb. and has an over-all length of 23 in. The extremely small head with which it is equipped permits using it in places normally inaccessible with other torque wrenches. It is permanently equipped with ½ in., square adaptor and can be used with all ½ in. square drive sockets and attachments.

"Imagine my embarrassment"

"EVER SINCE HECTOR was a pup our company has been sending our mechanical packing orders several hundred miles away. Just got into a buying rut, I guess. You can imagine my embarrassment when I found we could buy better packings right here at home. We not only got top-quality packings and quicker deliveries but it saved us money.

"The try-out packing job we turned over to our local mill supply salesman was a high pressure steam pump rod. He recommended Chesterton '64'—said it would probably hold on 10% longer than the former kind. Actually it gave us 33% better performance. And we didn't pay a penny extra for this packing.

"As he explained it afterward, Chesterton '64' is the only asbestos high pressure rod packing with *diagonal* plies. This construction feature means multiplied compressibility, fewer replacements, decreased packing expense. He also told me that his practical working knowledge of rod and sheet packings was largely the result of a Chesterton factory-supervised course of training.

Get acquainted with your local Chesterton trained distributor. He will not only help you select the right packing for the right job, but he can insure you prompt delivery because of his complete local stocks of Chesterton better-made packings. Then, too, in patronizing the Chesterton distributor, you also help keep business in your own community where it will do you the most good in the long run. You will find you can "buy better at home."

When ordering Chesterton "64" steam rod packing, order through *your* local mill supply house. If you do not know who your local Chesterton distributor is, write us.

Top-Quality Features:

1. Self-setting
2. No rubber back
3. Diagonal asbestos plies
4. Non-hardening binder

Order Today

through *your* Local Jobber

A. W. CHESTERTON COMPANY

64 India St. Boston, Mass.

PACKING Chesterton SERVICE

ALL CHESTERTON DISTRIBUTORS ARE FACTORY TRAINED MEN

News from the Field

ANNOUNCEMENT is made that the Semi-Annual meeting of the A. S. H. & V. E. will be held this year at Mackinac Island, Michigan, July 4 to 6. The Michigan Chapter of Detroit and the Western Michigan Chapter of Grand Rapids, will act as hosts to the society membership. William G. Boales of Detroit, general chairman of the meeting, will be assisted by Frank Feely of the Michigan Chapter and Tom Brown of the Illinois Chapter. O. D. Marshall of the Western Michigan Chapter, will be chairman of activities at the Island.

ACCORDING to announcement by P. R. Mork, vice president in charge of sales, L. H. Chamberlain, district manager of the Water Works Supply Co., Los Angeles, and the U. S. Pipe and Foundry Co., Los Angeles, since 1926, has been appointed manager of the water works sales section of Crane Co., Chicago.

GEORGE J. HELFRICH, who has been associated with the Reading-Pratt & Cady Division of American Chain & Cable Co., Inc., since 1925, has been appointed District Sales Manager of the Chicago territory with headquarters at 400 West Madison Street, Chicago, Ill.

DAVID DASSO on April 1 resigned as vice president of the Diesel Engine Division of the American Locomotive Co. but he continues as a consultant for the locomotive company and as the United States representative of Sulzer Bros., Ltd., of Winterthur, Switzerland.

STEEL SHIM STOCK in thicknesses 0.001, 0.002, 0.003 and 0.005 in. is now arranged for convenience in handling and use in cartons containing a roll 6 by 50 in. of each thickness, so that stock may be pulled from a slot and cut off as needed. The 0.001 in. stock is a new addition to the steel line. Thicknesses 0.001 by thousandths up to 0.01 in., also 0.012 and 0.015 are available in steel or brass in convenient packages. These shims are manufactured by Laminated Shim Co., 21-44, 44th Ave., Long Island City, N. Y.

ADVERTISING representatives of national corporations elected to the Board of Directors of the Exhibitors Advisory Council, Inc., are: J. F. Apsey, Jr., Advertising Manager, The Black & Decker Manufacturing Co., Towson, Md.; G. Van Alstyne, Advertising Manager, Air Reduction Sales Co., 60 East 42nd St., New York City; W. H. Dowd, Exhibit Manager, American Brass Co., Waterbury, Conn.; F. G. Page, Advertising Manager, Foster Wheeler Corporation, 165 Broadway, New York City.

ALBERT J. NESBITT, President of the Industrial Unit Heater Association announces the following committee appointments for the ensuing year: Engineering Committee: E. R. Walker, chairman, the Engineering Committee consists of a Chairman and one technical representative of each company; Finance committee: A. G. Dixon, Chairman, H. Mathis; Membership committee: M. F. May, Chairman, E. W. Petersen, P. Schoepflin; Publicity committee: T. Brown, Chairman, N. Downey; Trade Relations committee: Eastern Division, J. F. G. Miller, Chairman, H. S. Wheller. Western Division, J. M. Frank, Chairman, R. W. Nelson.

PUBLIC WORKS & BLDGS. DEPT. of Illinois has applied for license to build and operate power plants at Brandon Rd., Dresden Island and Starved Rock on the Illinois River with capacity of 43,650 hp., to cost $5,026,754. Dams, locks and intakes are already built. New development covers power house and equipment; of 13,000 hp. in two units at Brandon Rd.; 13,650 hp. in three units at Dresden; 17,000 hp. in four units at Starved Rock. Expected output is 176,251,200 kw-hr., to be sold to the highest bidder. Control will be by an administrative board of five members with State Director of Public Works as chairman.

A. F. DAVEY, manager of the Wisconsin Public Service Corporation's Sheboygan-Manitowac division, has been elected a director of the firm, filling the vacancy caused by the resignation of H. C. Cummins, of Minneapolis.

R. B. BRAGG has been appointed Yakima district manager for Pacific Power & Light Company, succeeding the late L. R. Sheeley. Mr. Bragg had been manager of the Walla Walla district since 1924. W. H. Till, formerly manager at Pendleton and more recently in charge of the company's new industries department, has been named Walla Walla district head to succeed Mr. Bragg.

W. G. BURNETT of Dallas, Tex., assistant secretary-treasurer of the Texas Power & Light Company, and Tom H. DeLay, of Tyler, were elected directors of the Texas Power and Light Company to fill vacancies on the board. At the same time the board re-elected 19 other directors and re-named John W. Carpenter president and general manager of the company for the twentieth time. Other officers re-elected were W. H. Thomson, vice president and assistant general manager; W. W. Lynch, Ted B. Ferguson, Edward T. Keck, W. G. Moore and G. B. Richardson, vice presidents; J. E. Van Horn, secretary-treasurer, and W. G. Burnett, assistant secretary-treasurer.

AMONG those appointed as heads of the committees which will shape the policies of the National Association of Manufacturers during 1939 was H. C. Beaver, president of the Worthington Pump & Machinery Corporation, Harrison, N. J. He was named chairman of the committee on healthful working conditions.

THE KENTUCKY TESTING LABORATORY of Lexington, Ky., has been absorbed by Foster D. Snell, Inc., of 305 Washington St., Brooklyn, N. Y. The laboratory has specialized in analysis of coal, water, building materials and similar lines. All equipment has been moved to the new location and the former personnel are part of the staff of Foster D. Snell, Inc. This broadens the analytical division of the Snell Laboratory and at the same time improves the service possible to former clients of the Kentucky Testing Laboratory.

ON MARCH 29, after an illness of ten days, death closed the career of Charles E. Cummings, head electrician of the University of Colorado. Mr. Cummings was born on Aug. 15, 1873, in Allen County, Ohio, and became associated with the university in 1905 as steam engineer and electrician. He retained his association with the university till the time of his death. He is survived by his widow, Mrs. Pearl R. Cummings, and two children, Lillian and Howard Cummings.

TWO LARGE ORDERS aggregating $850,000 have just been received by the Allis-Chalmers Mfg. Co. from the Central Illinois Public Service Co. of Springfield, Ill., and the Otter Tail Power Co. of Fergus Falls, Minn. The first order calls for a 25,000 kw., 3600 r.p.m., 650 lb., 825 deg. F. turbine and generator of the tandem compound type with a high pressure unit exhausting into a low pressure unit. It will be installed in the company's new Hutsonville Power Station at Hutsonville, Ill. Consulting engineers are Sargent & Lundy, Inc., Chicago.

The second order is for the Kidder Station of the Otter Tail Power Co. at Wahpeton, N. D. This is a 10,000 kw. generating unit and condenser designed to operate at 600 lb., 825 deg. F. It is said to be the first high pressure installation in that part of the country.

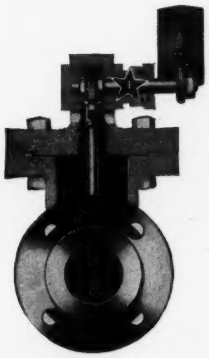
Austin to Increase Capacity

AS ANOTHER step in its power plant development program, the Board of Water, Electricity, Gas and Power Commissioners of Austin, Minn., early last month awarded a $122,000 contract for a 5000 kw. turbine generator to the Westinghouse Elec. & Mfg. Co. A condenser for the unit was ordered from the Worthington Pump & Mach. Corp. for $29,500. Carroll L. Elliott, General Superintendent, pointed out that during the past year the city's peak load increased 17.4 per cent or more than twice the average yearly increase of 7.4 per cent for the period from 1905 to 1940. The fact that the load is still increasing rapidly, plus a differential of only $30,000 between a 3500 and 5000 kw. machine led to the decision to buy the larger unit. This increase in generating capacity was anticipated by the installation last year of an 80,000 lb. per hr., 400 lb., 750 deg. F. boiler fired by a water cooled underfeed stoker. Helmick, Edeskuty & Lutz of Minneapolis are consulting engineers.

Dr. C. F. Hirshfeld

JUST AS we were going to press news was received of the death of Dr. C. F. Hirshfeld, Chief of Research of The Detroit Edison Co., internationally known educator and one of the most popular and versatile engineers in the power plant field. Since his graduation from the University of California in 1902 Dr. Hirshfeld played an intimate and important part in the industry. He died at Grace Hospital, Detroit, April 19, after an illness of several months. Additional details will be included in the next issue.

The COPES "5-STAR" BALANCED VALVE



★1 The horizontal rotating lever shaft reduces friction to less than 2 pounds in the largest sizes, compared with from 6 to 16 pounds or more with a sliding stem.

★2 High valve lift, from ⅝-inch on ¾-inch valves to 1⅝ inches on 6-inch, permits more accurate control and increases the life of the inner valve parts.

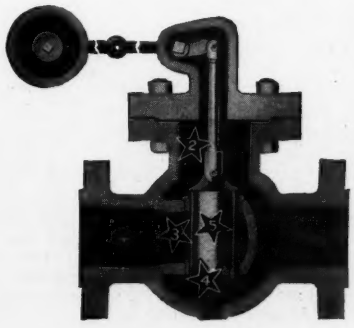
★3 Sleeve type or bevel-seating piston furnished as required by the operating conditions.

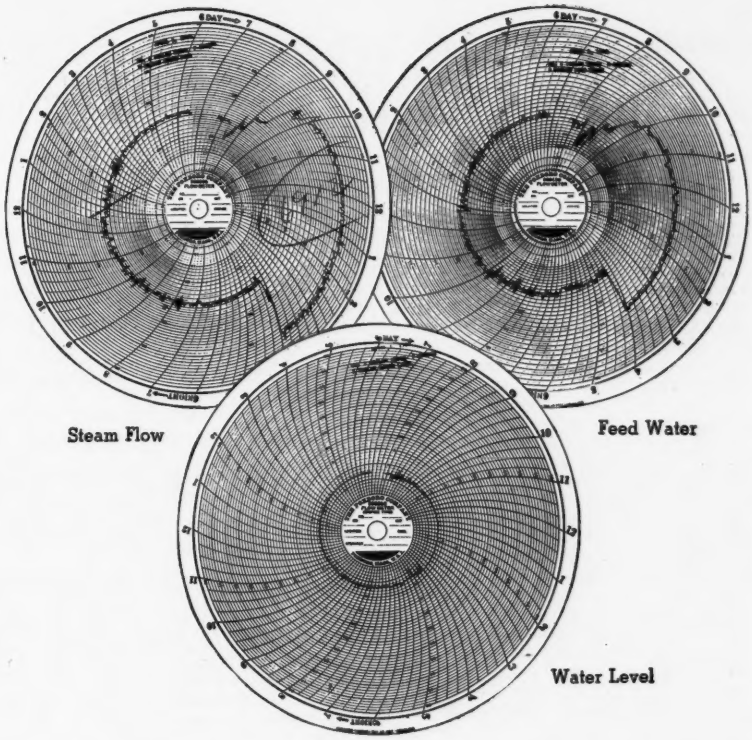
★4 Rectangular, "V" or compound ports are accurately designed for the operating conditions.

★5 Valve piston is scientifically balanced under flows and pressures, more so than any other make of "balanced" valve.

This "5-Star" Balanced Valve can be furnished for use with any actuating element. Or complete with solenoid, thrustor or motor for remote electrical control. Or with diaphragm operator for remote control by gas or air. For complete information—

Write for Control Catalog





Steam Flow

Feed Water

Water Level

A Large Refinery Reports

These charts show remarkably close boiler water level control—with accurate feed water regulation—outdoors on a 600-pound pressure Riley Generator. The Flowmatic Regulator was cut into service, adjusted and operated by the men on the job without "expert" supervision. If your loads vary widely, or swing rapidly, make sure of close water level control with the modern trouble-free COPES Flowmatic Regulator. Write for Bulletin 409-B.

NORTHERN EQUIPMENT CO., 512 GROVE DRIVE, ERIE, PENNA.

Feed Water Regulators, Pump Governors, Differential Valves
Liquid Level Controls, Reducing Valves and Desuperheaters

BRANCH PLANTS IN CANADA, ENGLAND, FRANCE, GERMANY, AUSTRIA AND ITALY . . . . REPRESENTATIVES EVERYWHERE

Get closer level control with the

COPES

FEEDS BOILER ACCORDING TO STEAM FLOW•AUTOMATICALLY

FLOWMATIC

★ REGULATOR

Eightieth Year for Hewitt

HEWITT RUBBER CORP., Buffalo, manufacturer of hose, conveyor, bucket elevator and transmission belting, and packings, is celebrating this year the 80th Anniversary of the founding in 1859 of the Gutta Percha and Rubber Mfg. Co., Hewitt parent company. In the 50's of the last century gutta percha ornaments became very popular in this country. A firm of New York manufacturing jewelers, Warren and Spadone, sensing the possibilities of crude rubber, began in a small way the production of these gutta percha ornaments. Their business in this new department grew so rapidly and their discoveries in the rubber industry were so remarkable that the making of jewelry, their original line of business, was discontinued entirely and the growth of the new industry carried on vigorously. From the start the Gutta Percha Co. manufactured fire hose.

In 1904 Herbert H. Hewitt founded the Hewitt Rubber Co. The firm's original intention was to confine itself to the manufacture and sale of products then coming into wide use in the railroad field. But as years passed and rubber found new uses in all fields of industry, the manufacturing lines of Hewitt became more diversified. In 1926, Hewitt acquired the business of the Gutta Percha and Rubber Manufacturing Co. that was founded, as previously mentioned, in 1859. During the following year the name of the company was changed to Hewitt-Gutta Percha Rubber Corp., under which name operations continued until 1933 when the name was shortened to Hewitt Rubber Corp. Hewitt's principal products are industrial hose, conveyor, bucket elevator and power transmission belting. Other products include molded and sheet rubber items.

The following comprise the Hewitt management, each officer having been with Hewitt ten years or more: Thomas Robins, Jr., President; Earle K. Twombly, Vice President and Treasurer; F. G. Cooban, Vice President; F. E. Miller, Vice President; W. S. Carleton, Vice President, in charge of Eastern Division; L. D. Bigelow, Vice President, in charge of Western Division; and J. H. Hayden, Secretary.

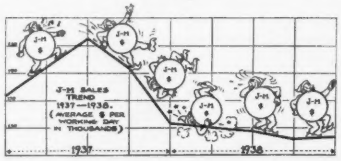
One Out of 5 kw. from Gas

FIGURES released recently by the Industrial Gas Section of the American Gas Association, indicate that 11 per cent of the output of the electric utilities is produced by gas. Gas sold to the utilities for electric power generation during 1938 was some 172,500,000,000 cu. ft. with an average heating value of 1100 B.t.u. Using an average steam plant efficiency figure of 22.8 per cent, this amount of gas was estimated to have produced some 12,650,000,000 kw-hr. of electric energy. E.E.I. estimates for 1938 placed the total electrical output at 113,850,000,000 kw-hr. of which 67,600,000,000 were produced in fuel burning plants. Thus approximately one out of every nine kilowatt-hours of electricity produced by the utilities was made from gas, or, one out of every five kilowatt hours produced in fuel burning plants was made from natural gas.

Federal Power Commission figures, which differ slightly from the E.E.I. figures because of a slightly different base, show a total gas consumption of 169,667,000,000 cu. ft. for 1938, a decrease of 1 per cent over the figures for 1937. The total electric energy production was 115,825,000,000 kw-hr., of which 71,747,000,000 were produced by fuel. The total figures show a decrease of 4 per cent from 1937, but due to the fact that water power production increased 1 per cent the total produced by fuel decreased 7 per cent from 1937 to 1938.

Dollar Division

IN HIS report on 1938 business, Lewis H. Brown, president of Johns-Manville, details and shows by interesting illustrations how the sales dollar varied in 1937 and 1938, also how it was split up among raw materials, research, power costs, depreciation, taxes and



other charges, leaving 35 cents of the dollar for workers, stockholders and reserve. Of this, workers got 32 cents, stockholders, who had an investment of $5472 per employee, got 2 cents, and 1 cent was put into reserve for future needs. Other interesting facts are included in the report, issued by Johns-Manville, 22 East 40th St., New York, N. Y.

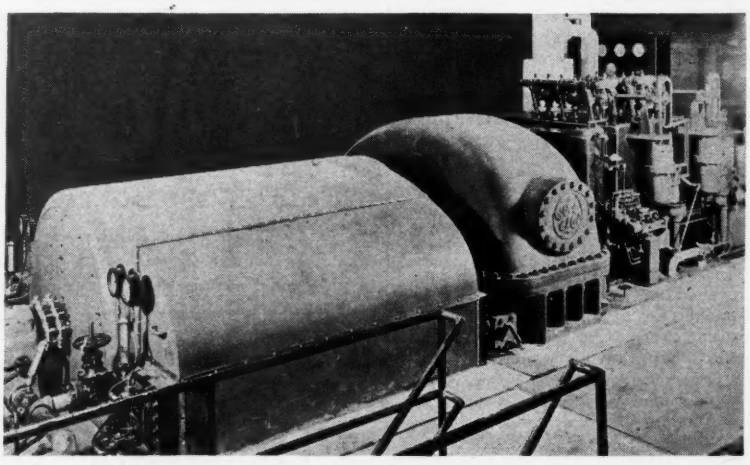
J. C. Springer

J. C. SPRINGER has been appointed as assistant credit manager of Cutler-Hammer, Inc., Milwaukee, Wis. He will assist W. E. Sargent, credit manager and assistant treasurer in connection with the company's complete line of motor control apparatus.

Mr. Springer, a graduate of the University of Illinois, has been with Cutler-Hammer since 1928. He served for several years in the Cleveland sales office of the company and for the past seven

J. C. Springer

years in the headquarters sales office at Milwaukee. His wide experience and familiarity with the apparatus and policies of the company, together with his intimate knowledge of the field, make him particularly well suited for his new duties.



Scott Paper Co.

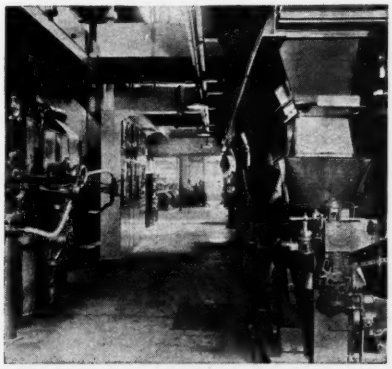
ANNOUNCEMENT has just been made by Edward S. Wagner, First Vice-President and Treasurer of Scott Paper Co., Chester, Pa., that the $2,500,000 program of plant manufacturing expansion begun last July is rapidly nearing completion. This program includes new power plant equipment, costing approximately $750,000, which is now in operation.

Steam generating facilities of the Chester plant have been increased from 250,000 to 320,000 lb. per hr. by the installation of a Combustion Engineering Type VU steam generator, with a capacity of 125,000 lb. per hr., 635 lb., 750 deg. F., in space provided by removing two older boilers.

Two Foster Wheeler evaporators with a total output of 30,000 lb. per hr. insure a continuous supply of condensate for boiler feed purposes.

A new General Electric double extraction condensing turbine rated at 5000 kw., 80 per cent power factor has increased the electrical output from 6000 to 11,000 kw. The extraction points are at 80 and 20 lb. pressure and the condenser vacuum is 28½ in.

STEAM COSTS ARE BEING CUT!



READ HOW THESE INDUSTRIAL PLANTS CUT THEIR STEAM PRODUCTION COSTS

• More steam for less money means increased profits. Read how these industrial plants made their boilers bigger money makers. Some installed new boilers—others revamped existing equipment —but they all installed Smoot Automatic Combustion Control to assure continuous operation at maximum efficiency. Find out if you can make similar savings by modernizing with Smoot Control!

Savings In Maintenance Pay For Controls

• Here is a good illustration of how an average sized plant that cannot afford elaborate remodeling can get the benefits of modern control developments that pay for themselves in hard cash. The chief engineer of a medium sized industrial plant had to get the best possible performance from his existing boiler equipment. Because of furnace design, it was hard to hold steam pressure, there was trouble from smoke and it was difficult to get good regulation of furnace draft and fuel feed. As a result, ignition was sometimes lost and refractories needed unduly large repairs every year. About 14 months ago, instead of paying for furnace rebuilding, which would have been necessary if existing operating methods had been continued, the engineer put the maintenance money into SMOOT control for his two 490-hp. chain-grate stoker-fired boilers. Result—a 50 per cent cut in furnace maintenance. This item alone was enough to pay for the control in 18 months. In addition, the steam pressure is being held constant and the smoke troubles have been eliminated. The complete story is told in folder No. 4-1-39. Write for a copy today if you are faced with a similar problem.

SAVE $950.00 PER MONTH During 7 Months of the Year

• Here is an excellent example of how steam costs can be cut by modernizing a power plant to take advantage of competitive fuel prices. A well-known hospital is now saving $950.00 per month during seven months of the year as a result of its modernization program. The remodeled plant, of 1600-hp. capacity, consists of three boilers burning gas and oil in a combination system. To assure maximum operating efficiency, the three boilers are equipped with a SMOOT combustion control system and REPUBLIC boiler instruments. The control system, in accordance with steam demands, regulates the flow of gas and oil to the burners and automatically maintains proper draft conditions. The complete story is told in folder No. 3-1-37. Write for a copy. Your request involves no obligation.

14% INCREASE In Boiler Efficiency

• This paper mill replaced 14 low-pressure boilers with one high-pressure, high-capacity unit under complete automatic control. As a result, boiler efficiency has been raised from 70 per cent to 84 per cent. The savings resulting from this increase in boiler efficiency have more than justified the cost of modernization. The operators attribute part of the success of the new installation to the SMOOT combustion control system. This system enables them to take full advantage of the economies "built into" the new unit. Steam pressure, steam temperature and furnace draft are maintained so constant that they appear as straight lines on the recorder charts. Read the complete story of this typical successful power plant improvement in folder No. 1-24-38.

• LOW STEAM COST is not the result of efficient boiler design alone! It is determined by the degree with which your method of boiler control takes full advantage of those economies which have been "built-in" the boiler!

REPUBLIC FLOW METERS CO.

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For the Engineer's Library

Any Catalogs that you wish will be gladly sent. Write Power Plant Engineering.

Pumps and Compressors

Pump Data Book—This is a 233-page book of engineering data and prices conveniently arranged in 17 divisions for the designer and user. The first half of the book covers pump prices, applications, installation data, etc., while the second half is devoted to tabulated engineering data, including auxiliary equipment such as safety switches, high water alarms, pressure switches, etc. The book will be sent free to engineers and pump users making application on their company letterhead; to others, the price is 60 ct. to cover cost of handling and mailing. Economy Pumps, Inc., Hamilton, Ohio.

Condenser Tubes—Condenser and Heat Exchanger Tube Manual, in a revised edition, is a 63-page book discussing the manufacturing methods, advantages of various alloys, tube failures, heat transfer and installation of condenser, heat exchanger and sugar tubes. Bridgeport Brass Co., Bridgeport, Conn.

Pumps—Four new bulletins illustrate four different types of pumps. The numbers and titles of the bulletins are as follows: W-341-B4, Centrifugal horizontally split two-stage heavy duty process pumps for refinery service, Type UT; W-341-B5, Centrifugal heavy duty process pumps, horizontally split, single-stage, Type LT, for refinery service; W321-B13, Monobloc pumps; W-450-B25A, Vertical turbine pumps for cofferdam dewatering and mine sinker service. Worthington Pump & Machinery Corp., Harrison, N. J.

Boilers and Accessories

Insulation — Falex Vermiculite, a light weight chemically inert, odorless, fireproof and vermin proof, high temperature mineral insulation for boilers and industrial furnaces is described in a new 4-page bulletin which includes technical data and heat loss curves for furnace walls of different thicknesses both bare and with from 1½ to 4 in. of insulation. Vermiculite may be used as a loose fill or plastic and is also suitable for making light weight insulating concrete weighing from 20 to 40 lb. per cu. ft. depending on the mixture. Faville-Le Vally Corporation, 140 So. Dearborn St., Chicago, Ill.

Mechanical Feed Water Regulation for Boilers is a 28-page paper bound book written by Edward P. Culver, Associate Professor of Mechanical Engineering at Princeton University. It is intended to acquaint the engineer with the progress that has been made in satisfactorily solving the feedwater regulation problem in modern power plants and to emphasize the fundamental principles of scientific feedwater regulation. Published by the Northern Equipment Co., 1945 Grove Drive, Erie, Pa.

Boilers—A new 40-page catalog describing bent-tube boilers has just come off the press. Two-, three- and four-drum types are covered, together with numerous setting arrangements. Included are various special designs of units for capacities ranging from 100,000 to 1,000,000 lb. of steam per hr. Combustion Engineering Co., Inc., 200 Madison Ave., New York, N. Y.

Boiler Gaskets—A new bulletin and price list illustrates two types of gaskets for manholes, handholes and tube caps of all standard makes of boilers. Goetze Gasket & Packing Co., Inc., New Brunswick, N. J.

Continuous Blow-down—The construction and installation of the Multometer system of continuous boiler blow-down is described in a new 6-page folder. P. E. Madden & Co., 352 W. Walton St., Chicago, Ill.

Air Handling

Air Receivers—The complete line of 23 standard air-receivers, available for maximum pressures of 125, 250, 350 and 500 lb., is described in a new folder just announced by the manufacturer. It is pointed out in the folder that every compressor should have adequate receiver volume in order to reduce pipeline pulsations, provide momentary reserve capacity, remove moisture and oil vapor, and assist in regulation of compressor capacity. Copies of the folder, Form 9202, are available from the Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

Humidifiers—A new 4-page bulletin illustrates and describes the Armstrong Humidifiers giving construction, operation and capacity ratings. Armstrong Machine Works, Three Rivers, Michigan.

Compressor—A new 28-page catalog, form 3063-A, on the Ingersoll-Rand line of "ES" compressors has just been published by the manufacturer. These machines, built in sizes from 10 to 125 hp. and pressures from 5 to 2500 lb., are of the double-acting, horizontal, crosshead type, designed to run at moderate speeds on heavy continuous service. Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

Axiflo Pressure Fans is the subject of a 20-page Catalog 444 giving the construction, applications and performance features of the products. A capacity table for each size fan is included in the catalog. B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Valves

Hydraulic Valve Actuator—Barnes Multi-Power Hydraulic valve actuators are described in Bulletin VA-100. These actuators are manufactured by the W. F. and John Barnes Co., Rockford, Ill., and are sold through the Automotive Temperature Control Co., Inc., 34 E. Logan St., Philadelphia, Pa.

Valves — Measurement of valve parts, welded bonnets, metals under heat, valves on an outdoor boiler are some of the topics treated in Valve Values for March, issued by Edward Valve & Mfg. Co., Inc., E. Chicago, Indiana.

Materials Handling

Electrical Equipment for Cranes—Bulletin C-5, entitled Electrical Equipment for Cranes, tells the whole story of the entire electrical equipment necessary for modern crane operation, covers thoroughly a.c. and d.c. crane motors of all types, hoist motors, mill-type and heavy-duty d.c. mill motors as well. It also describes the design and application of solenoid operated brakes, thrustor-operated brakes, and goes on to illustrate the many types of manual drum controllers, with speed regulation curves for both d.c. and a.c. operation. Harnischfeger Corp., 4400 West National Ave., Milwaukee, Wis.

Cranes—Bulletin C-6 entitled Industrial Cranes covers completely the design and application of the line of P&H Industrial Cranes for general usage in industries the world over. Starting with an illustrated review of crane history, this book contains complete, concise and detailed information. Harnischfeger Corp., 4400 West National Ave., Milwaukee, Wis.

Conveyor—Peck Overlapping Pivoted Bucket Carrier for the economical handling, elevating, conveying of coal, ashes, stone, cement, clinker, Fuller's earth, phosphate rock, and other materials, is described in a new 24-page illustrated catalog, No. 1720. Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill.

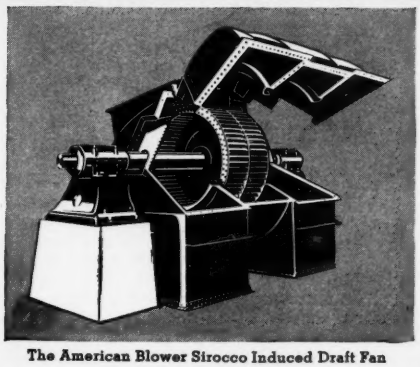
Diesel Engines

Engine Protection — Typical arrangements to protect internal combustion engines against damage, due to failure of lubricating oil or cooling water pressure, by the use of Fulton Sylphons are shown in a new 8-page leaflet, Form SF-522. The Fulton Sylphon Co., Knoxville, Tenn.

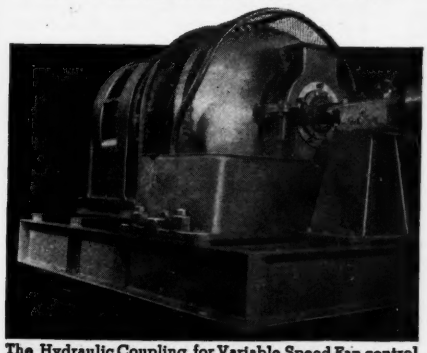
Diesel Engine—Bulletin S-500-B36 illustrates and describes the Type CC direct injection totally enclosed vertical four cycle Diesel engine. Worthington Pump & Machinery Corp., Harrison, N. J.

3 STEPS

TO *better* POWER PLANT PERFORMANCE



The American Blower Sirocco Induced Draft Fan



The Hydraulic Coupling for Variable Speed Fan control

The American Blower Dust Collector for minimizing the fly ash nuisance and reducing fan erosion

● The power plant engineer who is confronted with the problem of modernizing or expanding his facilities will do well to investigate these 3 steps:

1. **The application of Sirocco Induced Draft Fans.**
2. **Hydraulic Couplings for Variable Speed Fan control.**
3. **The installation of American Blower Dust Collectors for minimizing the fly ash nuisance and reducing fan erosion.**

It is a significant fact that power plant engineers and executives today are buying more American Blower equipment than at any other previous time in our history. Phone or write the nearest American Blower branch office for data. There is no obligation.

AMERICAN BLOWER CORP.

Division of American Radiator and Standard Sanitary Corp.

6000 Russell Street, Detroit, Mich. • Canadian Sirocco Co. Ltd., Windsor, Ont.

Power Plant Construction News

Ala., Montgomery — Construction Service, Veterans' Administration, Washington, D. C., is asking bids until May 16 for boiler plant in connection with several new buildings at institution at Montgomery, including boilers and complete auxiliary equipment, radial brick chimney, steel water tank and tower. Also for refrigerating equipment.

Calif., Hercules — Hercules Powder Co., 225 Bush Street, San Francisco, Calif., plans installation of power equipment in new addition to branch plant at Hercules, to be used for production of synthetic ammonia. Entire project is reported to cost over $400,000. Main offices are in the Delaware Trust Building, Wilmington, Del.

Calif., Santa Monica—Douglas Aircraft Co., Ocean Park Boulevard, plans installation of electric power equipment in new one-story addition to plant, 200x250 ft., to be used for assembling service. Entire project reported to cost over $175,000. Edward C. and Ellis W. Taylor, 803 West Third Street, Los Angeles, are architects.

Conn., Storrs—Department of Public Works, State Office Building, Hartford, Conn., R. A. Hurley, commissioner, has plans nearing completion for new boiler plant at institution at Storrs, to be used for central-heating service. Proposed to ask bids soon. Cost estimated about $160,000, with boiler units, pumps and auxiliary equipment.

Ill., Aurora — Western-Austin Co., Farnsworth Avenue, manufacturer of road machinery and kindred heavy equipment, plans installation of electric power equipment in new additions to plant, consisting of two one-story units, 120x520 ft., and 151x250 ft., respectively, including improvements in present works. Entire project will cost over $450,000. E. O. Sessions & Co., 120 South La Salle Street, Chicago, Ill., are consulting engineers.

Ind., Mishawaka—Indiana & Michigan Electric Co., South Bend, Ind., has approved plans for new addition to generating station at Mishawaka, including installation of new turbo-generator unit with capacity of 67,500 kw. and auxiliary equipment. Proposed to begin work soon. Thomas F. English is company manager at Mishawaka.

Iowa, Des Moines—Swift & Co., Oil Mill Division, Union Stock Yards, Chicago, Ill., plan installation of electric power equipment in new addition to mill at East Euclid and Delaware Avenues, Des Moines, to be used for soybean processing. Entire project will cost about $300,000. Company engineering department is in charge.

Iowa, Montezuma — City Council will have plans drawn soon for new municipal electric power plant. Proposed to use Diesel engine-generating units. Cost estimated about $136,000. Bond issue in that amount has been authorized at special election.

Kan., Kansas City—City Ice & Fuel Co., 6611 Euclid Avenue, Cleveland, Ohio, has concluded negotiations with city officials, Kansas City, for new cold storage and refrigerating plant on leased property in Public Levee District. Main unit will be one and two-story, 140x360 ft. Cost estimated close to $650,000, with equipment. Proposed to begin work this spring. Joseph W. Radotinsky, Commercial National Bank Building, Kansas City, Kan., is architect; Walter F. Schulz, Shrine Building, Memphis, Tenn., is consulting engineer.

La., Opelousas—St. Landry Parish officials plan installation of electric power equipment in new local cane sugar mill, for which a bond issue of $175,000 is being arranged. A power house will be built. Theodore Perriere, Balter Building, New Orleans, La., is architect in charge of project.

Md., Towson—Julien P. Friez & Sons, Division of Bendix Aviation Corporation, 4 North Central Avenue, Baltimore, Md., plans installation of electric power equipment in new plant for manufacture of aeronautical and other scientific instruments at Towson, where large tract of land has been acquired. A boiler house will be built. Entire project will cost close to $500,000, and is scheduled to begin soon. Glidden & Baldwin, 513 North Charles Street, Baltimore, are architects.

Neb., Wymore — City Council has plans under way for extensions and improvements in municipal electric power plant, to include installation of additional equipment. Cost estimated about $150,000. Proposed to ask bids at early date. E. H. Dunmire, 1802 B Street, Lincoln, Neb., is consulting engineer.

N. J., Edgewater—Lever Brothers Co., 164 Broadway, Cambridge, Mass., manufacturer of soaps, edible oils, etc., plans installation of electric power equipment in new addition to branch plant at Edgewater, used primarily for edible oil production. Cost estimated over $800,000. Stone & Webster Engineering Corporation, 49 Federal Street, Boston, Mass., is consulting engineer.

N. Y., Buffalo—General Mills, Inc., Chamber of Commerce Building, Minneapolis, Minn., manufacturer of cereal products, flour, etc., plans installation of electric power equipment in new branch mill at Buffalo, where site has been selected, to consist of several large units. Entire project will cost close to $2,000,000.

N. Y., Rochester—Eastman Kodak Co., Kodak Park, plans installation of electric power equipment in new seven-story addition to plant, to be used for processing of motion picture films. Entire project is reported to cost about $500,000. Completion is scheduled by close of year.

Ohio, Toronto—Ohio Edison Co., Youngstown, Ohio, has plans nearing completion for new addition to hydro-electric generating station at Toronto, with installation of additional equipment for increased capacity. Proposed to begin work this spring. Cost reported over $2,500,000, with station equipment, transmission lines, power substations and other structures. This is part of a $4,000,000 expansion and improvement program authorized by the company in 1939.

Okla., Ponca City—Continental Oil Co., Ponca City, and 60 East Forty-second Street, New York, N. Y., plan installation of power equipment in new oil refining plant in Ville Platte oil area, in Louisiana. Project will include a compressor station with two 400-hp. engine-driven compressor units and accessories, pumping plant and other mechanical divisions. Cost estimated close to $500,000. Work will be placed under way at once.

S. C., Charleston—Century Wood Preserving Co., Charleston, plans installation of power equipment in connection with rebuilding of portion of timber treating plant, recently destroyed by fire. A new boiler house is planned. Loss estimated close to $100,000.

Tenn., Knoxville—Tennessee Valley Authority, Knoxville, has plans in progress for new Watts Bar power and navigation dam in Tennessee River, about eight miles from Spring City, Tenn., and will secure part of required appropriation for project in July, according to schedule now being arranged. Dam will be 2930 ft. long. Hydroelectric generating plant will have an initial capacity of 90,000-kw. and ultimate output of 150,000-kw. Project will include transmission lines, power substations, switching stations and other structures. Estimated cost $35,000,000.

Tenn., Mount Pleasant — Victor Chemical Works, 141 West Jackson Boulevard, Chicago, Ill., plans installation of electric power equipment in connection with expansion and improvements in phosphate plant at Mount Pleasant, to include additional plant units for increased capacity. Entire project estimated to cost close to $850,000. Financing has been arranged. Work is scheduled to begin soon.

Texas, Houston—Bethlehem-International Supply Co., 7100 Clinton Drive, oil well machinery and supplies, plans installation of electric power equipment and material-handling apparatus in new one-story addition, 265 x 320 ft., for storage and distribution. Four overhead electric traveling cranes will be installed, as well as hoists, conveyors, etc. Entire project will cost close to $250,000.

Va., Arlington—R. O. Brannan, Woodstock Apartments, Lynchburg, Va., architect, representing a corporation whose name is temporarily withheld, is preparing plans for a new 15-story hotel in Arlington County, vicinity of the Potomac River, to include a boiler house for central-heating service for main hotel, garage and other buildings. An air-conditioning system will be installed, as well as ice refrigerating plant. Entire project will cost close to $5,000,000. Architect noted is in charge.

Wash., Seattle—Coca-Cola Bottling Co., 205 Roy Street, plans installation of electric power equipment in new bottling works on Cherry and Columbia Streets, and Thirteenth Avenue, one-story, estimated to cost about $150,000. Mechanical-handling equipment will be installed. Graham & Painter, Dexter-Horton Building, Seattle, are architects. Main offices of company are at Atlanta, Ga.